Editor's Overview

THE 14TH ISSUE OF THE *International Productivity Monitor* published by the Centre for the Study of Living Standards contains five articles. Topics covered are recent productivity developments in the United States; lessons for Canada from international productivity experience; India's productivity performance; measurement error and productivity growth in the Canadian construction industry; and the recently released EU KLEMS productivity and growth accounts.

The most important development in the US economy during the last decade has been the acceleration of productivity growth after 1995. Productivity growth is economic destiny so this trend, if sustainable, will deliver to the American people faster growth in material well-being. In the lead article, **Barry P. Bosworth** and **Jack E. Triplett** from the Brookings Institution focus on post-2000 productivity developments and find that the pace of productivity growth experienced during the second half of the 1990s has been maintained since 2000, with the driving force continuing to be the service sector.

The article represents an updating of the authors' important 2004 volume *Services Productivity in the United States: New Sources of Economic Growth.* They find that multifactor productivity growth in the services sector picked up after 2000 and was almost as high as that in the goods sector, an unprecedented historical development. They also note that reallocations of resources across industries, after reducing overall productivity growth before 2000, now appear to be playing a much more favourable role.

From an international perspective, Canada's productivity performance has been very poor during the last three decades, with our relative labour productivity level falling from third in the OECD in 1973 to 18th in 2006. This suggests that Canada has much to learn from international productivity experience. The second article by **Andrew Sharpe** from the Centre for the Study of Living Standards examines the factors that have fostered productivity growth in six OECD countries (United States, United Kingdom, Australia, Ireland, Sweden, and Finland).

Four important lessons for Canada emerge from the review. First, competition and productivity are closely intertwined. One of the most important steps, if not the most important step, governments can take to promote productivity is to ensure that markets are as competitive as possible. Second, human capital is the foundation of productivity advance, driving innovation. Third, the adoption of new technologies can be as important for productivity growth as the creation of new technologies through R&D. Fourth, institutional rigidities as a general rule impede productivity advance, while institutional flexibilities support it.

India has emerged in recent years as a dynamic economy with growing linkages to other countries. Indeed, the possibility of a Canada-India Free Trade Agreement has been raised. In the third article, **Joydeep Mukherji** from Standard and Poor's examines the productivity performance of the Indian economy and discusses the factors that are both driving and impeding productivity growth.

Mukherji argues that India has created the basic rules of modern political and economic life, the latter through economic liberalization policies. In his view, this institutional framework will allow India to become one of the fastest growing economies in the world during the next decade, in other words Asia's next productivity success story. But he feels India could go even better if it addressed its fiscal deficits, poor infrastructure, low level of human capital, and rigid labour laws.

The construction sector has been one of the pillars of the Canadian economy in recent years, with real GDP advancing at nearly a 6 per cent average annual growth rate since 2000. But measured labour productivity growth in the sector has been low, at 0.5 per cent per year only one third of that of the overall business sector over the 1981-2006 period. In the fourth article, **Peter Harrison** from Finance Canada examines the issue of whether measurement error can account for this weakness in labour productivity growth.

Harrison reviews the evidence that both supports and does not support the mismeasurement hypothesis. He identifies the use of input cost indexes for the deflation of nominal output, instead of the use of the more appropriate output price indexes, as the most likely source of measurement error. He finds that this procedure may have resulted in a downward bias to labour productivity growth in the construction sector of up to 0.44 percentage points per year over the 1981-2003 period. This would account for about one half of the gap in output per hour growth between the construction and business sector.

The importance of comprehensive, high-quality databases for productivity analysis and research cannot be overemphasized. On March 15, 2007, an important new international productivity database was released, the EU KLEMS growth and productivity accounts. In the fifth and final article in the issue, the developers of this database, **Marcel Timmer** of the University of Groningen, **Mary O'Mahony** from the University of Birmingham, and **Bart van Ark** from the University of Groningen, present an overview of this massive data gathering and synthesizing exercise. Productivity researchers will be long grateful to the authors, and to the European Commission for financing, for the creation of this public good.

These growth and productivity accounts include measures of output, employment, capital formation, and labour and multifactor at the industry level from 1970 onwards for 25 European Union countries as well as for the United States and Japan. The authors find that the numbers confirm the view that European countries experienced a significant and widespread slowdown in productivity growth since 1995, in contrast to pick-up in productivity growth that has characterized the United States.

The Early 21st Century U.S. Productivity Expansion is *Still* in Services

Barry P. Bosworth and Jack E. Triplett[1]
Brookings Institution

Abstract

Labour productivity in the U.S. non-farm business sector grew two and a half per cent per year during the 1995-2005 period, nearly double its growth rate over the previous two decades. Services sector labour productivity (LP) and multifactor productivity (MFP) grew more rapidly and substantially exceeded productivity accelerations in the goods sector. We show that the services sector accounted for three-quarters of U.S. MFP growth after 1995, and within services the contribution of MFP to LP growth exceeded the vaunted contribution of IT investment. We also find that the services sector has become even more important as the primary source of sustained productivity growth after 2000.

In this study, we compute LP, MFP and contributions to growth accounts for 57 industries within the goods and services sectors, using the new NAICS-based data set. We also show that resource reallocations, which are a newly important factor in productivity analysis, have changed the relation between increases in industry productivity growth rates and aggregate and sector growth rates in surprising ways.

Introduction and Summary

THE 20TH CENTURY ENDED WITH an unexpected surge in U.S. productivity growth. Labour productivity (LP) in the non-farm business sector grew two and a half per cent per year during 1995-2000, nearly double its growth rate over the previous two decades. In the opening years of the 21st century, Bureau of Labor Statistics estimates show that labour productivity has grown at three per cent per year, and somewhat less in the data we use for this article.

In Triplett and Bosworth (2006), Bosworth and Triplett (2007) and Triplett and Bosworth (2004),[2] we advanced an interpretation of the post-1995 U.S. productivity expansion that differed from the findings of other researchers (e.g. Oliner and Sichel, 2000; Jorgenson, Ho and Stiroh, 2000; and Gordon, 2000). Earlier studies focused on impressive multifactor productivity (MFP) growth in computer and semiconductor production, its resulting feedback into information technology (IT) investment in the rest of

1 Barry P. Bosworth is Senior Fellow and Jack E. Triplett Non-Resident Senior Fellow at the Brookings Institution in Washington, D.C. Earlier versions of this article were presented at the National Bureau of Economic Research Summer Institute, July 2006, and the annual meeting of the American Economic Association, January 5-7, 2007, Chicago, Illinois. We thank the participants, particularly our discussants Charles Hulten and Eric Brynjolfsson, for helpful remarks. Discussions with Robert Yuscavage of the Bureau of Economic Analysis provided essential inputs to this article. Gabriel Chodorow-Reich rendered superb research assistance and important suggestions. Emails: bbosworth@brookings.edu and jtriplett@brookings.edu

2 These studies are cited in the order written, which is of course, not the order published — our last work was published well in advance of the two conference volumes.

Table 1
Comparison of BEA/BLS and BLS Non-farm Business Labour Productivity, 1987-2005
(average annual per cent change)

Component	1987-95	1995-2000	2000-05
Output per hour			
BEA/BLS dataset	1.4	2.5	2.5
BLS	1.5	2.5	3.1
Output			
BEA/BLS dataset	3.0	4.8	2.4
BLS	3.0	4.7	2.6
Hours			
BEA/BLS dataset	1.6	2.3	-0.1
BLS	1.5	2.1	-0.5
Employment			
BEA/BLS dataset	1.7	2.5	0.2
BLS	1.5	2.2	-0.1

Source: Computed by authors as explained in text.

the economy, and the subsequent labour productivity (LP) growth in "IT-using" industries because of IT capital deepening.[3]

Unlike previous researchers, we examined productivity in services industries. We showed that strong MFP growth in the services sector transformed American economic performance after 1995. During the years of slow aggregate productivity growth (1973-1995), the services industries were marked by productivity stagnation in both LP and MFP, as Griliches (1992, 1994) pointed out. After 1995, services productivity accelerated strongly. In the revised Bureau of Economic Analysis/Bureau of Labor Statistics (BEA/BLS) data used for this article, services sector LP and MFP growth rates more than doubled after 1995. The acceleration of services sector LP substantially exceeded the more modest productivity acceleration in the goods sector.[4]

Strong services sector MFP growth is real news — and significant news. The services sector contributed three-quarters of the economy-wide acceleration in MFP after 1995, a contribution that is without historical precedent. Moreover, within services the contribution of MFP to LP growth exceeded the vaunted contribution of IT investment: More than half of the newly robust services sector LP growth came from the post-1995 acceleration of MFP growth.

Our results — that the services sector became the source of economic growth in the U.S. after 1995 — spawned a subsequent research topic: Why did European countries, and to a lesser extent Canada, not experience similar services-industries productivity growth?[5]

Confounding the predictions of some economists, U.S. productivity continued to advance in the new century, even though the late-90s IT investment boom ended and despite the recession of 2001. In this article, we extend our industries-

3 In this article, IT investment follows the BEA definition of information processing equipment and software: computer and peripheral equipment, software, and other information processing equipment (which includes communications equipment, instruments, copying machines and so forth). In 2005, software (43 per cent of IT investment) and other (38 per cent) were the largest categories, computer and peripheral equipment (19 per cent) the smallest. Though some economists use the term "ICT," we find it not a very descriptive acronym for the content of information processing equipment.

4 For this article, "goods sector industries" include manufacturing, mining and construction. "Services sector industries" include all other industries in the non-farm business economy, as defined by BLS and BEA. Government, of course, is not included. The BLS definition excludes non-profit organizations from the business economy, but BEA's industry data do not; the most important implication is that the medical care and education industries in our dataset include nonprofit hospitals, universities and so forth, but the industry definitions do not include government hospitals, for example, nor government primary and secondary education. The BLS non-farm business sector includes commercial real estate while our dataset excludes commercial real estate.

5 See, for example, O'Mahony and Van Ark (2003) and Inklaar and Timmer (2006). A subtopic grew out of this, mainly in the European policy-making setting: Is differential U.S.-E.U. services industry growth biased or illusionary because of differences in data across countries? The answer seems to be "no" (Inklaar and Timmer, 2006), though the stage of data development for industry productivity analysis differs greatly among OECD countries.

based approach to consider the post-2000 period. We find that the services sector has also maintained strong productivity growth in the post-2000 period. Late 20^{th} century and early 21^{st} century labour productivity growth was driven both by accelerating MFP growth in services and capital deepening. Labour productivity growth in the two periods thus has similar sources, and the second productivity advance is just an extension of the first.

On the other hand, *at the industry level* the picture has become more complex. Aggregation of industry productivities into sector and economy-wide levels requires allowances for resource reallocations. Productivity has greatly increased in services industries, but in recent years reallocation effects have been large and variable within the sector. For this reason, changes in productivity at the sector and aggregate levels differ from aggregated productivity change at the *industry* level. Reallocations are a new factor in the analysis of productivity growth.

Late 20^{th} and Early 21^{st} Century Productivity Expansions

Data

Recently, the Bureau of Economic Analysis has substantially improved its methodology for constructing its industry dataset, revised the data, and introduced the North American Industry Classification System (NAICS) to replace the old SIC system (Moyer *et al.*, 2004; Moyer, Reinsdorf and Yuscavage, 2006). These improvements, which incorporate improvements in the basic source data from the Bureau of Labor Statistics and the Census Bureau, add to earlier improvements (Lum, Moyer, and Yuscavage, 2000), and have transformed the U.S. industrial database to make it more useful for economic analysis than was in the past. The industry classification changes and the pertinent data revisions have been introduced into the BLS capital services measures, which provide the capital input measures for our MFP computations. Our data set covers 57 industries for the period 1987-2005.

Our estimates of labour productivity for the aggregate of non-farm business differ somewhat from the published BLS series. The two measures differ because the BEA industry data set includes nonprofit enterprises, which are excluded from the BLS measure. More important are some problems matching the employment data produced by BLS with the industry output measures, which are largely based on data originally collected by the Census Bureau. Differences in the industrial classification of enterprises between the business lists of Census and BLS raise concerns about the industry comparability of the data on employment and output. These concerns have been heightened by the different processes used by the agencies to convert the historical data to the new NAICS.

Previously, we relied on a measure of full-time equivalent employees plus the self-employed that was produced by the BEA. We believed it to be most consistent with the output data of the BEA and were distrustful of the industry-level data on hours worked. However, the BEA limited its conversion of the employment data prior to 1998 to a single series on the total number of employees. In addition, there are some problems with the post-1998 data on the self-employed and full-time equivalents that are yet to be resolved.

Alternatively, the Office of Employment Projections (OEP) of the BLS has produced estimates of employees, the self-employed and total hours for the earlier years, but these estimates have not yet been updated to 2005. We also noted that there are substantial differences in the number of employees for some industries as reported by the two agencies (Triplett and

Table 2
Productivity Growth in Non-farm Business, Goods, and Services Sectors, 1987-2005
(directly measured, average annual rate of change)

	1987-95	1995-00	2000-05
Labour Productivity			
Non-farm Business	1.4	2.5	2.5
Goods Sector	2.4	3.0	2.9
Services Sector	1.1	2.3	2.4
Multifactor Productivity			
Non-farm Business	0.9	1.6	1.7
Goods Sector	1.8	2.3	1.9
Services Sector	0.5	1.3	1.5

Source: Computed by the authors from the new NAICS-based industry data set, December 2006 release.

Bosworth, 2007). Thus, we opted to use the basic employee estimates of BEA multiplied by the ratio of total hours to employees for each industry from the BLS OEP. We held the estimate of hours per employee constant between 2004 and 2005.

As noted in the introduction, the data inconsistencies do create a discrepancy in the measures of labour productivity at the aggregate level of the non-farm business sector. These differences are documented in Table 1 for the interval of 1987 to 2005. While the differences are inconsequential in the early years, they are more significant for the 2000-05 period where our measure of output per hour rises at 2.5 per cent per year compared to 3.1 per cent for the published BLS measure. Most of this difference arises from a faster rate of growth in the labour input measure in our industry data set. The differences in LP growth are persistent over the five years, but they result from significant differences in employment growth in 2000-03 and 2005, and differences in output growth over the last two years. The BEA estimates of employment growth show a smaller decline in the 2001-02 recession and a larger increase in 2005. Coincidentally or not, the latest difference seems consistent with the recent benchmark adjustment to the BLS employment estimate.

On the other hand, the two series show similar short-run trends. Through 2004, they both indicated that post-2000 LP growth exceeded growth in 1995-2000, and they both record slowdowns since 2004. The latest BLS release (March 6, 2007) reports non-farm business sector LP growth of 2.1 per cent for 2005 and 1.6 per cent for 2006.

Productivity change in the 1995-2000 period

We first use the revised BEA-BLS data to re-estimate the productivity change analysis for the pre- and post-1995 periods covered in our book (Triplett and Bosworth, 2004). Our major finding — that productivity growth in the services sector accelerated much more after 1995 than productivity in the goods sector — is confirmed, even though revisions and the changes incorporated in the shift to NAICS have changed the magnitudes of the estimates considerably.[6]

Private non-farm productivity growth nearly doubled in 1995-2000 compared to 1987-95 (Table 2). Part of this development originated in the goods sector, where LP and MFP growth accelerated by about 30 per cent. More importantly, the growth rate of services sector LP and MFP more than doubled. This dramatic change in the services sector drove most of the famed revival of U.S. productivity growth.

At the sector level, data revisions, methodological improvements, and classification changes raised LP and MFP growth rates in the goods sector and lowered both the productivity growth rates and the magnitude of acceleration in the services sector. In the revised data, services sector productivity grew more slowly over

6 For our book (Triplett and Bosworth, 2004), data were only available through 2001. We now use the year 2000 as the break year, a more natural end point than 2001, which was a recession year. The results do not depend on the break year.

1995-2000 than the productivity of goods sector industries, but services were clearly catching up.[7] Since the services sector was by far the lagging sector in the pre-1995 period, its emergence as a contributor to productivity advance — particularly to MFP growth — was the most striking aspect of the post-1995 era. The extraordinary acceleration of services sector productivity has been too little noted and too much neglected.

Productivity change in the early 21st century — the aggregate and sector data

Defying many predictions, aggregate U.S. LP continued to advance after the recovery from the 2001 recession. The much-discussed second round of acceleration that some researchers detected in the BLS measure is less evident in the industry dataset. However, it shows that non-farm LP has advanced in the opening five years of the 21st century at the same rapid rate as in the last five years of the 20th century — 2.5 per cent per year. We calculate that aggregate MFP growth has held up as well, at 1.7 per cent per year, a healthy rate for an advanced economy.

The aggregated sectoral data in Table 2 indicate that U.S. productivity growth in the early 21st century has again taken place largely in the services sector, as it did in the closing years of the 20th century. Indeed, goods sector LP and MFP growth both declined after 2000. Services sector LP and MFP, on the other hand, continued to accelerate after 2000, to 2.4 per cent per year for LP and 1.5 per cent for MFP. The post-2000 services sector MFP acceleration is not as dramatic as in 1995-2000, but still its post-2000 growth is three times its pre-1995 growth rate. Non-farm business LP and MFP growth rates have held up in the face of declines in the goods sector rates because the services sector has made up the gap.

Services sector productivity growth rates still lag those of the goods sector, but the rates are converging. In the early 21st century, services sector LP and MFP are about 80 per cent of the corresponding rates for the goods sector. In the pre-1995 period, services productivity growth rates were from two-fifths (LP) to only one-quarter (MFP) of the goods productivity rates. For the services sector to have approached near parity in such a short time is one of the most remarkable — and overlooked — economic transformations of any era.

Sources of Productivity Growth

Sector level analysis

We use standard growth accounting methodology to decompose aggregate, sector, and industry LP growth into contributions from capital services, partitioned into IT capital services and other capital services, and from MFP (and for industry estimates, intermediate inputs). Our sectoral estimates are found in Table 3. We discuss our industry estimates later.

In the years 1995-2000, the United States experienced an investment boom, most of which was IT investment. Not surprisingly, then, nearly all of the capital contribution to non-farm LP growth during this period came from IT capital, as IT investment doubled its contribution to LP, compared to 1987-1995 (its contribution went from 0.4 to 0.8 points — see upper panel of Table 3). The IT contribution increased in both goods and services sectors by comparable amounts, but in the services sector, IT made up a larger part of the total capital contribution (nearly all — lower panels of Table 3).[8]

7 Earlier data suggested that services sector productivity growth exceeded that of the goods sector. The revised data show this is not yet the case. Classification changes account for part of the revision to the goods/services growth ratio.

Table 3
Non-farm Business, Goods, and Services Sector Labour Productivity Growth and Contributions, 1987-2005
(average annual per cent or percentage point change)

	1987-95	1995-00	2000-05
Non-farm Business			
Labour productivity	1.4	2.5	2.5
Capital contribution	0.5	0.9	0.8
of which: IT	0.4	0.8	0.5
Multifactor Productivity	0.9	1.6	1.7
of which: Computers	0.3	0.7	0.3
of which: Services	0.3	0.9	1.1
Goods sector			
Labour productivity	2.4	3.0	2.9
Capital contribution	0.5	0.7	0.9
Of which: IT	0.3	0.5	0.3
Multifactor Productivity	1.8	2.3	1.9
Services sector			
Labour productivity	1.1	2.3	2.4
Capital contribution	0.6	1.1	0.9
of which: IT	0.5	1.0	0.6
Multifactor Productivity	0.5	1.3	1.5

Source: Computed by the authors from the new NAICS-based industry data set, December 2006 release.

The capital contribution to non-farm business sector LP growth in 2000-2005 is nearly the same as in 1995-2000. However, the composition of investment changed after 2000. The IT boom ended and as others have observed, non-IT investment picked up some of the slack.[9] This was especially true for the goods industries, where the IT contribution fell in half, but where the overall capital contribution rose. In the services industries, the IT contribution also fell, as did the overall capital contribution, though only by 0.2 points.

Increasing IT investment in 1995-2000 has been well documented. But if IT boomed, MFP in services boomed even more.

Within the services sector, the MFP contribution to services LP, at 0.5 points previously, rose to 1.3 points in 1995-2000 (Table 3). MFP made an even larger contribution to services LP growth than provided by IT (1.0 points).

Not surprisingly, given the importance of services in the non-farm economy, the strong contribution of services MFP carried over to non-farm LP. Services MFP contributed more than a third of non-farm LP growth (0.9 points of the 2.5 per cent per year non-farm LP growth), about the same as the contribution to LP growth made by MFP in the production of computers.

Much of the recent productivity literature has examined accelerations, that is, the determinants of the increase in LP growth from 1.4 per cent per year before 1995 to 2.5 per cent after. Accelerations in growth contributions can be computed by reading across the rows in Table 3. Accelerating services sector MFP growth after 1995 contributed about the same to the LP acceleration as the much more widely acclaimed acceleration of MFP in IT: both contributed 0.5 points of the 1.1 point acceleration.[10] By this metric, as in others, MFP in services was a striking component to the advance in U.S. LP growth after 1995.

Turning now to the early 21st century expansion (right hand column of Table 3), all of the

8 Revised data have not changed the aggregate picture for 1995-2000, but they have changed the allocations between goods and services. Goods sector LP has been revised up sharply, and services LP revised down, but less so (services LP growth is now estimated at 2.3 per cent for the 1995-2000 interval, it was 2.6 per cent in the old data). The capital contribution has been revised down marginally in both sectors, but the IT portion has been revised up. In the new data, IT contributes relatively more to services LP than it did in the old data, and MFP contributes less. Compared to the new estimates for 1995-2000 in Table 3 (1.0 and 1.3 percentage points, for services sector IT and MFP contributions), the old were estimates were 1.0 and 1.5, respectively (Triplett and Bosworth, 2004, Table A-2, page 346).

9 The growth in capital intensity after 2000 also reflects the virtual disappearance of growth in employment.

10 The total acceleration from accelerating components exceeds 100 per cent, because there are components that decelerated. Thus, there is nothing inconsistent in the fact that the contributions of services MFP, IT MFP, and IT capital deepening add to more than the total acceleration.

modest increase in non-farm MFP, post-2000, took place in the services sector, where MFP continued to accelerate, though by a lesser amount (0.2 points, from 1.3 to 1.5 per cent per year). Moreover, growth in the MFP contribution, especially from services MFP, continued to drive non-farm LP growth after 2000. Indeed, services MFP advance was the sole source that supported aggregate LP growth. Every other contributor to non-farm business LP growth made a smaller contribution after 2000.

Judging from the aggregate and sector data, continued U.S. productivity growth in the post-2000 period is no surprise; it is just as an extension of the trends we described for the 1995-2000 period. Services sector MFP acceleration and economy-wide capital deepening continue to drive the non-farm business LP advance. The main difference in the early 21st century is the changed composition of investment — more contribution from non-IT investment — since the size of the total capital contribution remains nearly as high as it was at the end of the 20th century (and substantially greater than what it was before 1995).

Others who have contended that the late 20th and early 21st century productivity expansions were different have overlooked strong services sector productivity growth, the tie that binds them together. In particular, they have focused on the declining IT contribution after 2000. But as we have shown, though IT was a large contributor to LP acceleration after 1995, it was not the only one. Services MFP was also a major factor, and services MFP is the sole contributor to growth that held up and even accelerated after 2000. Overemphasis of the IT effect carries into economic analysis the "dot com" overemphasis from the period before 2000. IT is important. But it is not the only factor that is important. Crucially, IT is not the major contributor to recent productivity advance; MFP in services is.

Industry productivity growth rates and resource reallocations

Tables 2 and 3 show *direct* productivity measures — we aggregate value added to the sector and aggregate levels and then divide by the appropriate (aggregated) input concept. These tables do not show aggregated *industry* productivity growth rates.

We also compute industry productivity measures for LP and for MFP, for 24 goods industries and 33 services industries, using gross output in the numerator, rather than value added.[11] Indeed, we compute growth accounts for each of these 57 industries according to equation (1). This permits us to analyze productivity performance within sectors and across industries. We use gross output in our industry growth equations because value added implies very stringent conditions on the structure of production that have been decisively rejected empirically (for example, Berndt and Wood, 1975).

(1) $$\Delta \ln LP = s_{K_{IT}} \Delta \ln(K_{IT} / L) + s_{K_N} \Delta \ln(K_N / L) + s_M \Delta \ln(M / L) + \Delta \ln MFP$$

Within this model , capital services, K, are disaggregated into IT capital (K_{IT}) and non-IT capital (K_N), intermediate inputs — combined energy, materials, and purchased services — are designated as M, and the *s*'s denote two-period averages of the input shares.

We aggregate industry LP and MFP measures to goods and services sector levels and to the aggregate level. For the aggregation of industry LP growth measures, we use Stiroh's (2002) system:

11 The old BEA dataset had 25 goods industries and 29 services industries. Triplett and Bosworth (2004, Appendix Tables A-1 and A-2) present industry productivity results for these industries. Some activities (publishing, for example) were transferred across sectors in NAICS, so the goods-services boundary is not the same in the new and old data, and the BEA list of services industries differs appreciably.

(2) $$d\ln LP^V = \left[\sum_i w_i d\ln LP_i^Q\right] + \left[\sum_i w_i d\ln L_i - d\ln L\right] + \left[\sum_i m_i (d\ln Q_i - d\ln M_i)\right]$$

where

LP^V = aggregate value added per worker,

LP_i^Q = gross output per worker in industry i,

w_i = the two-period average of the share of industry i's nominal value-added in aggregate value-added, and

m_i = The two-period average of the ratio of industry i's nominal purchased inputs to aggregate value-added,

and of course, K, L, and M are the standard notations for capital, labour and intermediate inputs.

For the aggregation of MFP change, we use the generalization of the Domar weighting system presented in Jorgenson, Gollop and Fraumeni (1987):

(3) $$d\ln MFP^V = \left[\sum_i v_i d\ln MFP_i^Q\right] + \left[\sum_i v_i s_i^k d\ln K_i - \bar{s}^k d\ln K\right] + \left[\sum_i v_i s_i^l d\ln L_i - \bar{s}^l d\ln L\right]$$

where

v_i = two-period average of the ratio of industry i's gross output to aggregate value-added (Domar weights), and

s_i = the two-period average share in industry i of the designated factor's (K or L) income in nominal gross output,

MFP^V is aggregate MFP (computed on value added),

MFP_i^Q is industry MFP, for industry i, using gross output,

and other variables are defined in equation (2).

As the equations show, the direct non-farm and sector productivity measures discussed in the previous section reflect two forces — the effects of weighted changes in industry productivities and the effects of reallocations among industries. For the LP case in equation (2), the first term on the right-hand side are weighted industry LP estimates. The second and third terms measure inter-industry shifts in labour and intermediate materials usages, respectively. Note that the second term is the weighted average of industry labour input *growth* relative to overall labour input growth, and similarly for the intermediate inputs term.

Interpretations of the reallocation terms are not immediately intuitive. Consider a technological shock in industry A that raises MFP and thereby LP, and for the sake of the illustration we specify that technologies in other industries are unchanged. Unless the demand elasticity for industry A's output is high, industry A will use fewer resources. If the released resources go to industries with lower productivity growth rates, the reallocation reduces aggregate and sector productivity rates (the direct rates). Reallocations thus provide a partial offset to the direct impact on the sector rates from industry A's productivity gain.[12]

Reallocation effects have been large in recent years, and have changed signs from one period to the next. They have thus shifted the relation between aggregate and industry productivity growth in unpredictable ways. Our estimates are in Table 4.

Begin with the top panel of Table 4, which pertains to the non-farm business economy. The top line records the aggregation of LP growth in the 57 industries in our dataset, where individual industry LPs are aggregated using value added weights — the first term of equation (2). Aggre-

12 This is not an index number problem. We weight industry productivities with the 2-period average of value added. The reallocation problem concerns reallocations of inputs, not of the value added that serves as the weights.

gated industry LPs grew 1.9 per cent per year in the 1987-95 period, rising to 3.4 per cent in 1995-2000, then falling back to 2.5 per cent in 2000-2005. If industries roughly correspond to production functions, and ignoring the well-known non-technological factors that shift MFP,[13] the aggregated industry LP growth rate provides an estimate of the aggregated combinations of factor substitutions and technological shifts on LPs in the 57 industries.

The second and third lines of Table 4 show reallocations of labour and intermediate inputs, the second and third terms of equation (2). Subtracting the reallocations from the first line gives in the fourth line the direct sector productivity rates from Table 3. For the direct rates, aggregated value added is divided by aggregated labour.

Reallocations have typically reduced the direct productivity rates. For example, in the 1995-2000 period both reallocation terms had negative impacts. Together, they reduced aggregate LP growth by 0.9 points. During 1995-2000, the LP growth of industries in the non-farm economy expanded considerably faster than did aggregate non-farm LP growth.

Nearly all of the discussion of post-1995 LP growth in the U.S. has put that growth at 2.5 per cent per year (Table 2); yet, technological change and factor substitution at the industry level actually raised LP growth by 3.4 per cent per year in the 1995-2000 interval. Productivity at the industry level (which is where the productivity paradigm makes the most sense) was growing even faster than the aggregate number that received so much attention.

Similar calculations for sector productivity are presented in Table 4. These reallocations again use equation 2, but applied only within the sector (the reallocations within sectors do not add to total reallocations, because the latter include also reallocations between the sectors). At the sector level as well, the aggregated industry rates for 1995-2000 were substantially higher than the direct sector rates because the reallocations terms subtract from the aggregated industry LP growth rates. For example, aggregated LP in the services industries grew 3.5 per cent per year during 1995-2000, nearly double the pre-1995 rate, but services sector LP grew only 2.3 per cent per year.

Few productivity researchers have paid attention to resource reallocation effects.[14] For the question that most economists were exploring — how much did productivity improve after 1995? — reallocations did not matter. Using either the direct rates or the aggregated industry

Table 4
Labour Productivity by Sector and Reallocations, 1987-2005
(average annual per cent change)

	1987-95	1995-2000	2000-05
Non-farm business (aggregated)	1.9	3.4	2.5
Labour reallocation	-0.3	-0.1	-0.4
Intermediate input reallocations	-0.2	-0.8	0.4
Non-farm business (direct calculation)	1.4	2.5	2.5
Aggregated goods industries	2.3	3.2	2.2
Labour reallocation	-0.1	-0.3	-0.1
Intermediate input reallocations	0.2	0.1	0.7
Goods sector (direct calculation)	2.4	3.0	2.9
Aggregated services industries	1.8	3.5	2.7
Labour reallocation	-0.3	0.1	-0.5
Intermediate input reallocations	-0.4	-1.2	0.2
Services sector (direct calculation)	1.1	2.3	2.4

Source: Computed by the authors from the new NAICS-based industry data set, December 2006 release.

13 MFP is famously a residual. It can change with, in addition to technological shifts, measurement errors in outputs and inputs and changes in omitted variables, particularly intangibles and the coinvestments considered in much of the computer impact literature. See, among the large number of references that could be cited, Corrado *et al.* (2005) and Brynjolfsson and Hitt (2000).

14 An exception is Stiroh (2002, 2006).

rates, LP growth roughly doubled after 1995, and the post-1995 accelerations in the goods and services sectors were likewise similar. That reallocations reduced the sector and aggregate rates well below the industry rates was an intriguing curiosity, but one that suggested little of interest for the analysis of productivity growth.

In contrast, reallocations do matter for the most recent period. Net reallocations, a large negative number before 2000, were nil at the economy-wide level over 2000-2005. Substantial declines occurred in the industry LP rates, which fell from 3.4 to 2.5 per cent per year. But reallocations in 2000-2005 subtracted much less from the industry rates than they had earlier. Indeed, the decline in the magnitudes of the reallocation terms after 2000 coincidentally equaled the decline in the aggregated industry productivity rates, and left (as we noted earlier) the non-farm direct LP rate constant (at 2.5 per cent). Comparing 2000-2005 with 1995-2000, the direct non-farm LP growth rate held up, even as the aggregated industry LP growth rates declined from 3.4 per cent to 2.5 per cent, annually.[15]

The same was true of direct sector and aggregated industries rates in goods and services taken separately. In both cases, the direct sector rates held up after 2000 even as the aggregated industries LP growth rates fell because in both sectors the reallocation terms became less negative. Indeed, in the goods sector reallocations turned positive, led by strong positive intermediate materials reallocations, and boosted the direct LP growth rate (2.9 per cent) above the aggregated industries LP rates (2.2 per cent). To our knowledge, this is the first time net reallocations have been positive for any sector. In services, the decline in reallocations turned a decline in the industries' LP growth rates (of 0.8 points) into an increase of 0.1 point in the direct LP growth rate.

Shifts in reallocation terms interject a perplexing new variable into the analysis of post-2000 productivity growth. One can ask: have U.S. LP growth rates held up since 2000? The industry rates indicate that the answer to that is negative, for industry LP growth rates have fallen from 3.4 per cent to 2.5 per cent per year. But the direct rate has been maintained at 2.5 per cent, because the reallocations across industries have become less negative. In the early years of the 21st century, the U.S. economy is no longer shifting resources, as it did in previous times, toward the industries that have lower productivity growth.

Similar questions about goods and services sectors yield similar answers. As we have noted earlier, when measured by direct productivity rates, services sector LP growth accelerated slightly after 2000 (from 2.3 to 2.4 per cent per year), and goods sector LP growth decreased imperceptibly (from 3.0 to 2.9 per cent). However, aggregating the goods industries' and services industries' LP growth rates, we find (Table 3) that they both fell, compared to end of the 20th century rates. Goods industries' LP growth rates dropped more (from 3.2 to 2.2 per cent), but services industries' LPs also fell (from 3.5 to 2.7 per cent).

Interpretation

The sustainability of recent U.S. productivity performance is a question of great current interest. Much of the analysis of sustainability has employed reasoning that draws on the factor substitution contribution to LP growth (for example, through IT capital deepening), and secondarily on technical change at the industry level. But since resource reallocations have recently made substantial, and fluctuating, contributions to sector and aggregate productivity growth, reallocations are a third factor that must be brought into consideration.

More favorable reallocation effects may also be part of the complex of favorable circum-

15 Note that aggregation of the industry productivity rates (equals 2.5 per cent) equals the direct rate, because reallocations net out in 2000-2005. This was not the case earlier.

stances that the U.S. economy enjoyed in recent years. Denison (1962) emphasized the shift of laboor out of (then) low productivity agriculture as a force for improving U.S. productivity. The United States may have returned to a period where resource shifts play once again a positive role in U.S. productivity growth. But this, as with much discussion of productivity prospects that others have entertained, is speculative.

Because so little attention has been paid to reallocation effects, it is worth noting that BEA data and procedural revisions have greatly increased their post-1995 estimated values. The revisions left the overall 1995-2000 direct LP growth rate relatively unchanged. However, the industry LP rates were raised, especially within the services sector, as were the sizes of the reallocation effects. Because BEA's methodological changes caused more integration of the industry accounts and the input-output accounts, they may have improved the measurement of inter-industry flows in the industry accounts. The new estimates of reallocation effects may be revealing an economic phenomenon that was probably always important in industry productivities, but was hidden by the less effective methodology of the past.[16]

We think that further analysis of reallocation effects is needed. For example, recent U.S. productivity performance relative to the European Union (EU) has provided much fodder for policy discussions. The frequently-encountered idea that less regulation in the United States (relative to the EU) is the source of its better productivity performance rests on the interpretation that *aggregate and sector* LP growth is the result of production function shifts and capital-labour substitution. Some of it, instead, reflects the U.S. economy's recent more favorable shift of resources into subsectors that have higher productivity growth. Until we know more about the nature of those resource shifts, one cannot claim that deregulation (or other favored nostrums) will augment them favorably, no matter how attractive are the intellectual cases to be made for less regulation.[17]

Services Industry Productivity Measures

As we have used it, the BEA industry dataset contains 23 goods-producing industries and 34 services industries, at roughly the 3-digit level of the NAICS classification. Productivity advance, post-2000, remains broadly based both in goods and in services industries.

As Table 5 shows, 70 per cent (16 of 23) of goods industries and 65 per cent of services industries (22 of 34) experienced more rapid LP growth after 1995, considering the whole 1995-2005 period together.[18] For MFP, the picture is similar: 57 per cent of the goods industries and 65 per cent of the services industries showed accelerating productivity, again considering the whole period 1995-2005 compared with pre-1995. Thus, goods and services industries advanced in MFP in roughly similar proportions for the period after 1995. Productivity advance in U.S. industries — MFP as well as LP — was not narrowly located in electronics, contrary to assertions that have often been repeated.

16 Triplett and Bosworth (2004, Table 2-5) computed reallocation terms and discussed them, but they appeared smaller in the data that were available at the time.

17 Lest we be misinterpreted, we share the usual economists' presumption against excessive regulation. What we are saying is that the empirical case linking deregulation to accelerating U.S. sector and aggregate LP and MFP measures is weak, and is weaker still when the substantial roles of reallocation effects are considered.

18 The old BEA dataset used for our book contained 29 services industries. We reported in our book that productivity growth increased in 18 of the 29, comparing 1995-01 to the pre-1995 period (Triplett and Bosworth, 2004, page 17). Allowing for the changed number of industries (choice of end point—2000 or 2001—made no difference), this is essentially the result noted above.

Table 5
Industry Productivity Accelerations, 1987-2005

	1995-00/ pre-1995	2000-05/ pre-1995	1995-2005/ pre-1995
Number of goods industries	23	23	23
Per cent accelerating LP growth	57	74	70
Per cent accelerating MFP growth	43	70	57
Number of services industries	34	34	34
Per cent accelerating LP growth	62	68	65
Per cent accelerating MFP growth	53	65	65

Source: Computed by the authors from the new NAICS-based industry data set, December 2006 release.

Non-accelerating industries

There are 10 contrary services industries — those for which LP and MFP growth over the combined 1995-2005 interval failed to accelerate, compared with pre-1995 rates.[19] Four are in transportation. They deserve further study. Only trucking has any kind of productivity literature — our trucking industry measures derived from BEA and BLS data seem inconsistent with Hubbard's (2003) results.

Of the other six industries, a number present measurement problems. The Federal Reserve and credit intermediation industry (negative MFP or LP growth rates in at least one period) is not only a somewhat miscellaneous grouping, it is likely distorted with the error created by the inappropriate national accounts measure of the output in financial institutions.[20] Education is the sick child of services productivity, with measured LP and MFP that is negative and growing more so; the output of the industry, and therefore its productivity, may be mis-measured, but education may also be the archetypal "Baumol's disease" industry (Baumol 1967). Performing arts and amusements are now also negative productivity growth industries; no research exists on productivity in these growing industries. The negative rates in "other services except government" are hard to assess.

Better output measurement would likely turn some of these seeming laggards into better productivity performers. On the other hand, we also suspect mismeasurement in some industries that show high measured LP growth rates. Airline transport — whose measured LP growth became strongly positive, post-2000 — may be overstated.

MFP and lagged investment in IT

Basu and Fernald (2006) explore whether MFP growth is a function of lagged investment in IT. They reason that increasing (measured) MFP may result from omission from the capital input measures of unobserved intangible capital and "coinvestments" that are associated with investment in IT (many other authors have advanced the same hypothesis). They take the share of IT in industry value added as a proxy for the unobserved investments. Basu and Fernald report evidence that they characterize as "somewhat consistent" with the lagged hypothesis. Basu *et al.* (2004), in a paper that uses a version of the data for our book, reported similar findings for the 1995-2000 period.

We looked at this question briefly in our book (Triplett and Bosworth, 2004: 29-31). We found no relation between the IT intensity of an industry (we used the share of IT in capital services) and its subsequent MFP growth. We examine the question again with our new data.

We computed several regressions of industry MFP change on its lagged IT. In the regression whose results were most favorable to the lagged IT hypothesis, we used the ratio of IT capital income to value added as the measure of industry IT intensity (this measure is close to the Basu and Fernald measure).[21] Thus, our regression includes as right-hand variables the current five-year period's IT intensity (expected to have a neg-

19 The growth accounting results for all 57 industries are posted at www.csls.ca/ipm/4.asp.

20 See chapters 5 and 7 of our book (Triplett and Bosworth, 2004) and Basu, Inklaar and Wang (2006).

Table 6

OLS Regression of IT Intensity Level on MFP Growth[1]

		IT Intensity	Lagged IT Intensity	Double Lagged IT Intensity	Adjusted R-squared	Observations
All Industries	1995-00	-12.17	13.82		-0.03	57
		(0.31)	(0.37)			
	2000-05	-128.00*	146.94*		0.16	57
		(3.48)	(3.59)			
	2000-05	-128.00*	124.69*	23.46	0.17	57
		(3.46)	(2.71)	(1.05)		
Services	1995-00	-42.12	38.43		-0.02	34
		(1.17)	(1.12)			
	2000-05	-44.60	55.61		-0.02	34
		(0.98)	(1.09)			
	2000-05	-38.87	21.26	30.39	0.01	34
		(0.86)	(0.38)	(1.38)		
Goods	1995-00	98.02	-13.86		-0.01	23
		(0.62)	(0.07)			
	2000-05	-246.00*	257.59*		0.41	23
		(3.85)	(4.11)			
	2000-05	-233.00*	189.17	84.33	0.40	23
		(3.48)	(1.68)	(0.74)		
Goods ex. Computers	1995-00	87.67	-104.00		0.01	22
		(1.52) -	(1.34)			
	2000-05	89.53	100.58		-0.05	22
		(0.9)	(1.02)			
	2000-05	-50.60	-23.27	129.51	-0.02	22
		(0.49)	(0.16)	(1.21)		

Source: Authors' calculations as explained in text.

1 IT Intensity is the ratio of IT capital income to Value-Added.

Notes: The items in parentheses are t-statistics. The regressions also included a constant term (not shown).

* indicates significance at the 1% level of a two-tailed t-test.

ative sign, on the grounds that resources are being diverted to coinvestments without a current payoff), the IT intensity of the previous period (e.g., for 1995-2000 the lagged IT for 1987-1995, expected to have a positive sign, as coinvestments begin their payout), and IT intensity lagged two periods (available for the post-2000 period only). Table 6 shows the results.

Scanning down the columns, most of the signs are consistent with the hypothesis —negative on current IT, positive on lagged IT, but coefficients are mostly statistically insignificant. At the all-industries level, signs are correct and statistically significant only for post-2000, not for 1995-2000. Possibly Basu *et al.*'s significant findings for 1995-2000 are casualties of data revisions.

21 In another, we used the IT capital contribution to industry LP as the measure of IT intensity. Entered into a lagged regression it yielded very low t-values and essentially zero adjusted R^2, so we did not consider this formulation further. There is no natural measure of IT intensity (Triplett and Bosworth, 2006 discuss nine alternatives), and rankings of industries by IT intensities are not invariant to the measure chosen.

We then disaggregated our investigation, running separate regressions for goods industries and services industries. For services industries, signs were correct in both periods, but t-values were weak. For goods, as in the all-industries regression, signs were correct for post-2000 (but not for 1995-2000), and t-values for post-2000 were highly significant. Examination of the data for individual industries suggested running another goods industry regression with the computer and electronics industry deleted: The results resemble the results for services — signs for the post-2000 period (only) remain correct but t-values drop to insignificance. When the second lagged variable is included in this regression, it has the expected sign, but the first lagged variable becomes negative. In any case, however, none of the coefficients is significant.

We conclude from this that the computer and electronics industry is not only an outlier, but that it has a tremendous impact on the goods industries and all industries regressions. Computer and electronics production has the highest MFP growth in our dataset (11.00 and 6.17 per cent per year for, respectively, 1995-2000 and 2000-2005), and it is not IT nor capital intensive by our value added measure. Outside of this industry, the lagged IT hypothesis has no statistical support in the industry data set. If the hypothesis describes something about IT investment, then empirically it *must* reveal itself in services industries because 80 per cent of U.S. IT investment is in the services sector.

Undoubtedly, investment in computers requires coinvestment. Lags are likely before the full potential of these investments are realized. However, we think these are properties of all investment and not particular or unique properties of computers.

Many of the management changes that have launched the revival of U.S. productivity growth are IT-enabled changes — computer equipment and software were required to put into effect the innovations that managers sought to make.[22] However, for the management resources used to make thousands of different innovations across our 57 diverse industries to be strongly correlated with the amount of IT used in each of these innovations would be an unlikely coincidence. The contribution of management inputs, coinvestment and intangible investment to recent productivity advance needs exploration. Indeed, our findings of major acceleration in MFP in services industries serves to confirm the importance of looking for other input variables, since growth in MFP can be a sign that something is omitted from the analysis. We believe, though, that finding the sources of the surge in MFP growth that has marked the U.S. economy over the last decade will require a great effort to enumerate and measure those omitted variables. Tempting as it may be to short-circuit the measurement process with ever more elaborate econometrics on the measures we already have, it is unlikely (as Zvi Griliches was fond of pointing out) to work.

Computers and semiconductors

In the previous literature on the post-1995 productivity advance, a great amount of ink was spilled recording indirect estimates of the rate of productivity advance in the electronics sector. The estimates had to be indirect because in the old U.S. SIC classification system, computers were buried, as we have remarked before, with drill bits in industrial machinery, while semiconductors were in the same industry as Christmas tree lights. The new NAICS classification system contains a computer and electronics manufacturing subsector, so in our data we can form a direct estimate of LP and MFP growth for this important industry. Our estimates are in Table 7.

22 Eric Brynjolfsson, the discussant for this article at the 2007 AEA session in Chicago, remarked that one could think of IT investment being a function of management innovation equally well as coinvestment being a function of IT and computers. The investments and the associated changes in organization and methods of doing business are all wrapped up in one decision process.

MFP growth in computers and electronics has been dazzlingly rapid. Even before 1995, it exceeded 5 per cent per year, and reached 11 per cent during 1995-2000 (MFP calculated consistently with the gross output growth accounting equation (1)). This latter estimate is somewhat below that of Jorgenson, Ho and Strioh's (2002), who estimated 16.8 per cent per year for computers and 18.0 per cent for electronics for the same period. Oliner and Sichel (2002) estimated 14.0 per cent for computer MFP growth and 45.2 per cent for semiconductors for 1995-2000; both are components of the present BEA industry, but other elements are included as well. Using our present data, at its height this one industry's MFP contributed 0.70 percentage points to non-farm LP growth, which is not far from the contribution that Oliner and Sichel obtained from quite indirect methods. [23]

One service industry had comparable LP and MFP growth rates — securities and commodities exchanges. Brokerage MFP, at nearly 11 per cent, had the second fastest MFP growth in 1995-2000, and again in 2000-2005. Its contribution to non-farm LP was lower because it is a smaller industry, about half the size of computer and electronics manufacturing in terms of value added.

Table 7

MFP in Computers and Brokerage Firms, 1987-2005

(average annual per cent or percentage point change)

	1987-95	1995-00	2000-05
Computers			
Industry MFP growth	5.7	11.0	6.2
MFP contribution to non-farm LP	0.33	0.70	0.27
Brokerage Firms			
Industry MFP growth	4.9	10.8	4.9
MFP contribution to non-farm LP	0.09	0.35	0.17

Source: Authors calculations from the new NAICS-based industry data set, December 2006 release.

Conclusion

In an otherwise excellent recent review of the post-1995 productivity expansion, Anderson and Kliesen (2006: 181) state: "...economists have reached a consensus that...the underlying cause of that increase [in U.S. labour productivity in the 1990s] was technological innovations in semiconductor manufacturing... ." If this is indeed the consensus, we contend it is wrong.

Two forces, not one, drove the 1995-2000 productivity expansion: Investment (much of it in IT) and MFP, much of the latter in services industries. Anderson and Kliesen focus, as did the researchers who preceded our work, on the contribution of IT investment (capital deepening) and MFP in IT production, without considering at all the contribution of MFP acceleration in services industries.[24] The advance in productivity that began in 1995 is a widespread phenomenon that was caused by more far-reaching economic forces than merely the rate of technical advance in the production of semiconductors (though we do no minimize the importance of technical change in electronics production and of capital deepening in raising U.S. LP).

We examine in this article the post-2000 productivity expansion, using our industry productivity approach. We again find that productivity growth was driven by capital deepening, this

23 The entries for contributions in Table 7 differ from the corresponding ones in Table 2 because Table 2 presents direct non-farm business sector LP, and the direct LP growth rate is based on value added. In interpreting these numbers, the reader should bear in mind that because productivity decelerated in some industries, the industries in which productivity accelerated contributed more than 100 per cent of the total acceleration.

24 On services productivity, Anderson and Kliesen (2006:184) state: "Increased use of ICT capital was the primary cause behind the productivity acceleration." They then quote from our book a passage in which we said that IT capital deepening in the U.S. was a services industry story. But we did not say that services productivity was an IT story — a very different thing. IT made a contribution to services labour productivity, but more remarkable was the acceleration of MFP growth in the services industries (see Triplett and Bosworth, 2004, Table A-2). In the data then available, services LP grew 2.56 per cent per year, of which IT contributed 1.01 points and MFP 1.48 points.

time not primarily in IT, and by productivity advance in services industries, especially MFP in services. The notion that the U.S. productivity revival rests fragilely on possibly transitory technological changes in one technologically dynamic industry is not consistent with the U.S. industry productivity data and has led to mistaken analysis and too pessimistic forecasts.

However, the industry productivity aggregations have brought to the fore a new factor: Resource reallocations have fluctuated in recent years, and estimates of their size have increased with BEA revisions to its industry accounts. Since 2000, reallocations have boosted services sector productivity change relative to services industry productivity change. It is still true that the foremost transition in the U.S. economy after 1995 was the revival of U.S. services industries. But whether early 21st century productivity growth has held up (to 1995-2000) or whether it has fallen short, depends on how one asks the question: Measured at the sector level, productivity growth has held up; at the industry level, LP growth has fallen.

MFP is a residual, after accounting for all contributing inputs. If variables are not measured appropriately, or if crucial inputs are omitted, then MFP growth may indicate where mismeasurement is worsening. The mismeasurement hypothesis (initially explored by Jorgenson and Griliches, 1967) provides the bridge to our complementary paper (Triplett and Bosworth, 2007), where we assess the adequacy of services sector data.

References

Anderson, Richard G. and Kevin L. Kliesen (2006) "The 1990s Acceleration in Labor Productivity: Causes and Measurement," *Federal Reserve Bank of St.Louis Review*, May-June, pp. 181-202.

Basu, Susanto, John G. Fernald, Nicholas Oulton and Sylaja Srinivasan (2004) "The Case of the Missing Productivity Growth: or, Does Information Technology Explain Why Productivity Accelerated in the United States but not in the United Kingdom?" *NBER Macroeconomic Annual* (Cambridge: MIT Press).

Basu, Susanto and John G. Fernald (2006) "Information and Communications Technology as a General-Purpose Technology: Evidence from U.S. Industry Data," San Francisco Federal Reserve Bank Working Paper 2006-29, September.

Basu, Susanto, Robert Inklaar, and Christina Wang (2006) "The Value of Risk: Measuring the Services of U.S. Commercial Banks," paper presented at the NBER Summer Institute, Cambridge, Mass.

Baumol, William J. (1967) "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis," *American Economic Review*, Vol. 57, No. 3, pp. 415-26.

Berndt, Ernst R. and David O. Wood (1975) "Technology, Prices, and the Derived Demand for Energy," *Review of Economics and Statistics*, Vol 57, No. 3, August, pp. 259-268.

Bosworth, Barry P., and Jack Triplett (2007) "Services Productivity in the United States: Griliches' Services Volume Revisited," in Ernst R. Berndt and Charles M. Hulten, eds. *Hard-to-Measure Goods and Services: Essays in Memory of Zvi Griliches* (Chicago: University of Chicago Press), forthcoming.

Brynjolfsson, Eric, and Lorin Hitt (2000) "Beyond Computation: Information Technology, Organizational Transformation, and Business Performance," *Journal of Economic Perspectives*, Vol. 14, No. 4.

Corrado, Carol, Dan Sichel and Charles Hulten (2005) "Intangible Capital and Economic Growth" in Carol Corrado, John Hultiwanger and Dan Sichel, eds. *Measuring Capital in the New Economy* (Chicago: University of Chicago Press).

Denison, Edward F. (1962) *The Sources of Economic Growth in the United States and the Alternatives Before Us*, Supplementary Paper No. 13 (New York: Committee for Economic Development).

Gordon, Robert (2000) "Does the 'New Economy' Measure up to the Great Inventions of the Past?" *Journal of Economic Perspectives*, Vol. 14, Number 4, pp. 49-74.

Griliches, Zvi (1992) "Introduction," in Zvi Griliches, ed., *Output Measurement in the Service Sectors*, National Bureau of Economic Research Studies in Income and Wealth, Vol. 56 (Chicago: University of Chicago Press), pp. 1-22.

Griliches, Zvi (1994) "Productivity, R&D, and the Data Constraint," *American Economic Review*, Vol. 84, Number 1, pp. 1-23.

Hubbard, Thomas N. (2003) "Information, Decisions and Productivity: On Board Computers and Capacity Utilization in Trucking," *American Economic Review*, Vol. 94, No. 4, September, pp. 1328-1353.

Inklaar, Robert and Marcel P. Timmer (2006) "Accounting for Growth in Retail Trade: An International Productivity Comparison," Groningen Growth and Development Centre, University of Groningen, March.

Jorgenson, Dale W. and Zvi Griliches (1967) "The Explanation of Productivity Change," *Review of Economic Studies*, Vol. 34, Number 33, July, pp. 249-83.

Jorgenson, Dale W., Frank M. Gollop, and Barbara M. Fraumeni (1987) *Productivity and U.S. Economic Growth* (Cambridge, Mass.: Harvard University Press).

Jorgenson, Dale W., and Kevin J. Stiroh (2002). "Raising the Speed Limit: U.S. Economc Growth in the Information Age," *Brookings Papers on Economic Activity*, Number 2, pp. 125-211.

Lum, Sherlene K.S., Brian C. Moyer and Robert E. Yuscavage (2000) "Improved Estimates of Gross Product by Industry for 1947-98," *Survey of Current Business*, Vol. 80, Number 6, pp. 24-54.

Moyer, Brian C., Mark A. Planting, Mahnaz Fahim-Nader, and Sherlene K.S. Lum (2004) "Preview of the Comprehensive Revision of the Annual Industry Accounts," *Survey of Current Business*, Vol. 84, No. 1, March, pp. 38-51.

Moyer, Brian C., Marshall Reinsdorf and Robert E. Yuscavage (2006) "Aggregation Issues in Integrating and Accelerating the BEA's Accounts: Improved Methods for Calculating GDP by Industry," in Dale W. Jorgenson, J. Steven Landefeld and William D. Nordhaus, eds. *A New Architecture for the U.S. National Accounts*, NBER Studies in Income and Wealth, Vol. 66 (Chicago: University of Chicago Press).

Oliner, Stephen D., and Daniel E. Sichel (2000) "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?" *Journal of Economic Perspectives*, Volume 14, Fall, pp. 3-22.

O'Mahony, Mary, and Bart van Ark (2003) *EU Productivity and Competitiveness: An Industry Perspective* (Luxembourg: Office for Official Publications of the European Communities).

Stiroh, Kevin (2002) "Information Technology and U.S. Productivity Revival: What Do the Industry Data Say?" *American Economic Review*, Vol. 92, Number 5, pp. 1559-76.

Stiroh, Kevin (2006) "The Industry Origins of the Second Surge of U.S. Productivity Growth," Federal Reserve Bank of New York Working Paper, July.

Triplett, Jack E. and Barry P. Bosworth (2004) *Services Productivity in the United States: New Sources of Economic Growth* (Washington, D.C.: Brookings Institution Press).

Triplett, Jack E. and Barry P. Bosworth (2006) "'Baumol's Disease' Has Been Cured: IT and Multifactor Productivity in U.S. Services Industries," in Dennis W. Jansen, ed. *The New Economy and Beyond: Past, Present, and Future* (Cheltenham, U.K.: Edgar Elgar).

Triplett, Jack E. and Barry P. Bosworth (2007) "The State of Data for Services Sector Productivity Measurement," unpublished paper, Brookings Institution.

Appendix Table 1
Sources of Growth in Gross Output per Worker, 1987-2005
(average annual percentage change)

				Contribution of:											
	Gross output per worker			Capital per worker			IT capital per worker			Intermediate inputs per worker			Multifactor productivity		
Industry	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**
Private Nonfarm (except real estate)	1.46	3.15	1.89	0.24	0.45	0.42	0.21	0.41	0.26	0.74	1.91	0.59	0.46	0.77	0.87
Goods-sector	2.28	2.74	2.02	0.19	0.26	0.34	0.11	0.19	0.09	1.40	1.61	0.92	0.67	0.85	0.74
Forestry, fishing, and related activities	-1.73	-2.66	-0.18	0.11	-0.73	-0.49	0.16	-0.07	-0.06	0.21	-2.66	0.76	-2.04	0.74	-0.45
Mining	2.65	2.73	-1.58	0.79	0.56	-0.14	0.18	0.21	0.14	0.57	2.62	0.98	1.27	-0.44	-2.39
Oil and gas extraction	3.27	3.94	-2.28	1.15	1.31	-0.12	0.04	0.12	-0.03	0.43	4.53	-0.67	1.66	-1.86	-1.50
Mining, except oil and gas	4.20	2.77	1.79	0.02	0.68	0.25	0.17	0.37	0.13	1.61	-1.85	3.11	2.52	4.00	-1.52
Support activities for mining	1.05	7.39	-0.49	-0.14	-0.20	-1.16	0.06	0.17	-0.06	0.57	9.68	4.68	0.62	-1.90	-3.83
Construction	-0.28	0.71	0.76	-0.07	0.49	0.23	0.07	0.22	0.09	-0.29	1.32	1.09	0.08	-1.09	-0.55
Manufacturing	2.93	3.96	3.67	0.27	0.43	0.46	0.14	0.25	0.12	1.86	2.22	1.77	0.78	1.26	1.40
Durable goods	3.94	5.55	4.16	0.23	0.44	0.39	0.14	0.27	0.12	2.46	2.75	1.82	1.22	2.27	1.89
Wood products	-0.21	1.51	1.65	-0.05	0.12	0.09	0.08	0.09	0.04	0.43	1.77	0.71	-0.59	-0.38	0.83
Nonmetallic mineral products	0.69	1.35	2.60	-0.05	0.14	0.45	0.07	0.18	0.14	-0.70	0.66	1.06	1.45	0.54	1.07
Primary metals	2.47	0.41	6.08	-0.01	-0.03	0.28	0.03	0.04	0.03	1.74	-0.34	3.96	0.73	0.78	1.75
Fabricated metal products	1.44	1.19	0.71	0.09	0.20	0.38	0.12	0.17	0.11	0.77	0.99	-0.43	0.58	-0.01	0.76
Machinery	2.47	2.58	3.61	0.30	0.96	0.58	0.20	0.62	0.29	2.18	2.14	1.71	-0.02	-0.52	1.28
Computer and electronic products	13.51	19.74	8.11	0.55	0.74	0.05	0.25	0.40	0.02	6.83	7.08	1.78	5.67	11.00	6.17
Electrical equipment, appliances, and components	3.29	3.15	2.94	0.56	0.31	1.10	0.16	0.13	0.17	2.09	2.55	0.46	0.60	0.28	1.35
Transportation Equipment (NAICS 336)	2.38	3.26	4.37	0.14	0.41	0.31	0.10	0.25	0.13	2.35	2.73	3.31	-0.12	0.10	0.72
Furniture and related products	1.06	2.98	4.60	0.20	0.36	0.53	0.07	0.14	0.10	0.82	2.11	2.49	0.04	0.48	1.53
Miscellaneous manufacturing	2.92	2.24	5.38	0.20	0.19	0.47	0.15	0.18	0.14	1.02	0.77	2.10	1.67	1.27	2.74
Nondurable goods	1.70	2.24	3.13	0.31	0.49	0.54	0.14	0.23	0.12	1.11	1.80	1.73	0.28	-0.05	0.83
Food and beverage and tobacco products	1.40	0.43	1.73	0.16	0.06	0.16	0.06	0.09	0.05	0.73	1.34	1.44	0.51	-0.96	0.12
Textile mills and textile product mills	2.38	2.25	4.28	0.10	0.20	0.37	0.03	0.04	0.01	1.13	1.71	1.95	1.14	0.34	1.91
Apparel and leather and allied products	2.57	5.49	-0.71	0.49	0.93	1.07	0.06	0.14	0.09	1.21	3.97	-2.86	0.86	0.54	1.14
Paper products	1.67	0.76	3.00	0.29	0.27	0.28	0.11	0.14	0.07	1.62	0.53	1.04	-0.23	-0.04	1.66
Printing and related support activities	0.46	1.55	1.08	0.19	0.44	0.65	0.12	0.27	0.18	0.25	1.24	-0.68	0.03	-0.13	1.12
Petroleum and coal products	3.24	4.02	0.75	0.31	0.22	0.23	0.13	0.12	0.16	3.34	2.88	0.27	-0.41	0.88	0.24
Chemical products	1.36	2.20	2.23	0.56	0.86	0.47	0.34	0.53	0.14	0.81	1.34	0.34	-0.02	-0.01	1.41
Plastics and rubber products	1.98	2.37	3.27	0.13	0.46	0.65	0.06	0.11	0.08	0.99	1.00	1.82	0.85	0.90	0.76

Appendix Table 1 (con't)

Sources of Growth in Gross Output per Worker, 1987-2005

(average annual percentage change)

	Gross output per worker			Contribution of: Capital per worker			IT capital per worker			Intermediate inputs per worker			Multifactor productivity		
Industry	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**
Service-sector	**1.37**	**3.59**	**2.21**	**0.34**	**0.61**	**0.51**	**0.29**	**0.57**	**0.36**	**0.75**	**2.28**	**0.79**	**0.28**	**0.67**	**0.89**
Utilities	3.58	3.43	1.78	1.18	1.25	1.94	0.31	0.36	0.46	0.94	1.53	-1.05	1.42	0.62	0.91
Wholesale trade	3.49	4.29	2.96	0.34	1.08	0.64	0.21	0.64	0.34	1.68	0.29	0.84	1.44	2.88	1.44
Retail trade	2.78	3.94	3.65	0.42	0.35	0.33	0.17	0.21	0.14	0.68	1.04	1.29	1.67	2.50	1.99
Transportation and warehousing	1.28	1.88	1.50	-0.27	0.44	0.10	0.13	0.50	0.17	0.45	0.62	0.31	1.09	0.81	1.08
Air transportation	0.58	3.62	7.70	0.09	1.43	0.72	0.19	1.29	0.53	-1.13	-0.05	3.54	1.64	2.22	3.27
Rail transportation	5.80	3.23	5.44	0.30	0.53	0.36	0.08	0.11	0.01	2.40	1.25	3.30	3.00	1.42	1.70
Water transportation	3.04	2.32	-2.58	-0.08	0.21	-0.13	0.07	0.37	0.22	0.85	1.73	-1.20	2.26	0.36	-1.26
Truck transportation	3.19	2.21	-0.40	-0.28	0.19	-0.19	0.08	0.21	0.10	1.91	2.21	-0.88	1.54	-0.19	0.67
Transit and ground passenger transportation	-0.32	-1.72	-2.13	-0.09	0.55	0.20	0.08	0.35	0.19	0.09	-2.70	-1.28	-0.32	0.46	-1.06
Pipeline transportation	1.17	5.52	5.38	0.23	1.06	0.38	0.32	0.43	0.06	0.57	2.87	3.67	0.37	1.51	1.26
Other transportation and support activities	-1.48	1.51	0.33	-0.70	0.31	-0.16	0.21	0.71	0.09	0.23	-0.05	-0.74	-1.02	1.25	1.24
Warehousing and storage	2.02	2.18	2.70	-0.42	0.22	0.13	0.17	0.25	0.36	0.78	-0.30	0.60	1.66	2.27	1.95
Information	3.27	5.64	8.02	0.84	0.91	1.24	0.63	1.14	0.91	1.34	4.50	3.51	1.06	0.18	3.07
Publishing and data prcessing	3.46	4.30	7.30	0.54	0.29	1.11	0.55	0.59	0.78	2.16	2.99	1.72	0.73	0.98	4.34
Motion picture and sound recording industries	-0.40	-0.35	2.25	0.23	-0.08	-0.28	0.20	-0.10	-0.07	0.68	0.33	0.17	-1.30	-0.59	2.37
Broadcasting and telecommunications	4.07	7.54	9.29	1.36	1.51	1.58	0.91	1.73	1.21	0.95	6.33	5.14	1.70	-0.36	2.33
Finance and insurance	1.72	6.22	1.77	1.33	1.44	0.67	0.79	0.83	0.36	0.45	4.26	0.30	-0.06	0.44	0.79
Federal Reserve banks, credit intermediation, and related	1.86	2.97	-0.36	2.94	2.68	0.21	1.70	1.78	0.36	1.23	3.42	-1.60	-2.24	-3.04	1.05
Securities, commodity contracts, and investments	8.69	21.69	5.57	0.22	0.10	-0.10	0.15	0.14	-0.09	3.37	9.72	0.75	4.92	10.79	4.89
Insurance carriers and related activities	-0.17	-0.02	3.04	1.14	0.91	0.66	0.67	0.45	0.41	-1.21	0.08	3.19	-0.09	-1.00	-0.80
Funds, trusts, and other financial vehicles	-2.46	9.17	5.85	-0.10	0.34	0.57	0.00	0.03	0.00	-2.47	12.70	4.39	0.11	-3.46	0.83
Rental and leasing services and lessors of intangible assets	2.93	5.47	2.80	1.67	6.02	2.75	1.08	3.19	1.12	1.46	3.83	3.73	-0.23	-4.18	-3.55
Professional and business services	0.31	3.74	3.23	0.24	0.33	0.77	0.22	0.52	0.61	0.78	2.99	1.32	-0.70	0.39	1.11
Professional, scientific, and technical services	1.05	5.10	4.49	0.26	0.32	0.69	0.23	0.56	0.63	0.98	3.36	2.00	-0.20	1.36	1.74
Legal services	-0.22	1.62	3.02	0.06	0.10	0.16	0.03	0.11	0.12	0.18	1.42	1.72	-0.46	0.10	1.11

Appendix Table 1 (con't)

Sources of Growth in Gross Output per Worker, 1987-2005

(average annual percentage change)

				Contribution of:											
	Gross output per worker			Capital per worker			IT capital per worker			Intermediate inputs per worker			Multifactor productivity		
Industry	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**
Computer systems design and related services	2.71	4.56	3.16	0.14	0.87	0.96	0.29	1.16	0.90	1.92	3.15	-0.55	0.63	0.49	2.75
Miscellaneous professional, scientific, and technical services	1.32	6.29	5.17	0.32	0.21	0.80	0.27	0.51	0.73	1.19	4.09	2.57	-0.19	1.89	1.72
Management of companies and enterprises	-0.49	-0.10	1.99	0.23	0.19	0.80	0.21	0.22	0.66	0.27	0.95	0.83	-0.98	-1.22	0.35
Administrative and waste management services	1.14	3.69	1.49	0.21	0.47	0.95	0.24	0.62	0.56	1.32	3.71	0.21	-0.38	-0.48	0.33
Administrative and support services	1.31	4.13	1.59	0.25	0.61	1.03	0.25	0.70	0.60	1.43	4.12	0.23	-0.36	-0.60	0.33
Waste management and remediation services	1.81	2.49	-0.39	0.36	-0.13	0.05	0.24	0.11	0.16	1.65	1.68	-0.57	-0.20	0.93	0.14
Educational services, health care, and social assistance	-0.34	0.40	1.23	0.26	0.07	0.24	0.28	0.19	0.32	0.83	1.16	0.63	-1.43	-0.82	0.36
Educational services	0.41	0.01	-0.32	0.05	0.17	0.26	0.07	0.15	0.15	0.87	0.75	-0.21	-0.51	-0.90	-0.36
Health care and social assistance	-0.48	0.50	1.43	0.27	0.08	0.23	0.30	0.21	0.33	0.83	1.23	0.74	-1.56	-0.80	0.44
Ambulatory health care services	-1.17	0.83	1.61	0.10	-0.04	0.22	0.25	0.22	0.48	0.97	1.46	0.53	-2.21	-0.59	0.85
Hospitals and nursing and residential care facilities	-0.14	0.29	1.00	0.27	0.26	0.20	0.28	0.22	0.18	0.93	1.16	1.16	-1.32	-1.12	-0.36
Social assistance	0.11	1.50	1.64	-0.14	-0.19	0.05	0.07	0.11	0.07	-0.09	1.15	-0.17	0.34	0.53	1.76
Arts, entertainment, recreation, accommodation, and food services	0.73	0.92	0.19	0.08	0.08	0.08	0.07	0.10	0.08	0.79	0.42	0.28	-0.15	0.42	-0.17
Arts, entertainment, and recreation	3.33	1.45	-1.02	-0.04	0.65	0.42	0.01	0.09	0.09	2.29	0.75	-0.70	1.06	0.04	-0.74
Performing arts, spectator sports, museums, and related	4.44	3.43	-1.18	0.14	0.24	0.44	0.02	0.10	0.11	2.60	1.56	-1.22	1.65	1.59	-0.40
Amusements, gambling, and recreation industries	2.19	-0.04	-0.82	-0.31	0.72	0.43	0.01	0.09	0.08	1.95	0.11	-0.23	0.55	-0.86	-1.02
Accommodation and food services	0.09	0.83	0.52	0.10	0.36	0.11	0.05	0.07	0.08	0.42	0.33	0.57	-0.43	0.14	-0.16
Accommodation	0.89	0.58	0.29	0.30	0.51	-0.16	0.06	0.07	0.07	0.39	0.59	1.16	0.19	-0.52	-0.71
Food services and drinking places	-0.15	0.90	0.65	0.06	0.29	0.25	0.05	0.07	0.09	0.41	0.24	0.34	-0.61	0.37	0.06
Other services, except government	1.65	1.82	0.45	0.29	-0.24	0.10	0.15	0.18	0.09	1.25	2.43	0.70	0.10	-0.35	-0.34

Appendix Table 2

Sources of Growth in Value Added per Worker, 1987-2005

(average annual per cent or percentage point change)

				Contribution of:								
	Value added per worker			Capital per worker			IT capital per worker			Multifactor productivity		
Industry	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**
Private Nonfarm (except real estate)	1.40	2.49	2.51	0.48	0.89	0.83	0.42	0.82	0.52	0.92	1.58	1.67
Goods-sector	2.36	3.01	2.85	0.52	0.70	0.91	0.30	0.53	0.25	1.83	2.29	1.93
Forestry, fishing, and related activities	-3.88	-0.21	-1.86	0.25	-1.56	-0.97	0.33	-0.14	-0.12	-4.12	1.38	-0.90
Mining	3.99	0.53	-4.35	1.60	1.11	-0.17	0.35	0.41	0.28	2.35	-0.57	-4.19
Oil and gas extraction	5.26	-0.59	-2.61	2.27	2.49	-0.12	0.09	0.23	-0.05	2.92	-3.01	-2.50
Mining, except oil and gas	5.63	8.92	-2.07	0.05	1.39	0.45	0.38	0.76	0.26	5.58	7.43	-2.50
Support activities for mining	0.85	-2.85	-10.89	-0.24	-0.28	-2.55	0.11	0.35	-0.12	1.09	-2.58	-8.56
Construction	0.03	-1.18	-0.60	-0.14	0.98	0.45	0.14	0.44	0.17	0.17	-2.13	-1.05
Manufacturing	3.13	5.07	5.57	0.80	1.28	1.37	0.41	0.74	0.36	2.31	3.74	4.14
Durable goods	3.96	7.70	6.39	0.61	1.25	1.08	0.37	0.76	0.33	3.33	6.37	5.26
Wood products	-1.96	-0.78	2.67	-0.19	0.37	0.29	0.22	0.28	0.10	-1.77	-1.15	2.37
Nonmetallic mineral products	3.43	1.54	3.22	-0.09	0.30	0.95	0.19	0.40	0.30	3.52	1.24	2.25
Primary metals	2.58	2.57	7.15	-0.04	-0.08	0.96	0.09	0.15	0.10	2.62	2.65	6.13
Fabricated metal products	1.50	0.43	2.55	0.20	0.44	0.87	0.27	0.38	0.25	1.30	-0.01	1.66
Machinery	0.73	1.09	4.82	0.69	2.48	1.46	0.47	1.61	0.74	0.04	-1.35	3.31
Computer and electronic products	17.38	35.27	18.66	1.45	2.08	0.15	0.67	1.10	0.05	15.71	32.52	18.49
Electrical equipment, appliances, and components	2.58	1.47	5.41	1.22	0.77	2.46	0.35	0.32	0.37	1.34	0.69	2.88
Transportation Equipment (NAICS 336)	0.07	1.88	3.54	0.49	1.48	1.08	0.35	0.89	0.46	-0.41	0.39	2.44
Furniture and related products	0.55	1.98	4.71	0.47	0.84	1.22	0.17	0.32	0.23	0.09	1.13	3.44
Miscellaneous manufacturing	4.37	3.15	6.73	0.44	0.41	0.98	0.33	0.38	0.30	3.91	2.73	5.70
Nondurable goods	1.94	1.45	4.49	1.03	1.58	1.78	0.47	0.74	0.39	0.90	-0.13	2.67
Food and beverage and tobacco products	2.62	-3.17	1.25	0.69	0.26	0.62	0.27	0.38	0.21	1.92	-3.42	0.63
Textile mills and textile product mills	3.97	1.80	7.43	0.31	0.66	1.19	0.10	0.12	0.03	3.64	1.13	6.17
Apparel and leather and allied products	3.45	4.13	4.95	1.24	2.60	2.51	0.16	0.40	0.22	2.19	1.49	2.38
Paper products	0.15	0.68	5.87	0.86	0.80	0.87	0.34	0.41	0.22	-0.71	-0.12	4.96
Printing and related support activities	0.46	0.65	3.61	0.40	0.94	1.36	0.26	0.58	0.38	0.06	-0.28	2.22
Petroleum and coal products	-0.42	7.49	3.98	2.01	1.63	1.59	0.82	0.85	1.09	-2.38	5.77	2.34
Chemical products	1.55	2.25	5.06	1.64	2.35	1.28	0.98	1.43	0.37	-0.09	-0.10	3.73
Plastics and rubber products	2.69	3.61	3.85	0.36	1.21	1.75	0.17	0.30	0.22	2.32	2.37	2.07
Service-sector	1.06	2.34	2.43	0.55	1.06	0.89	0.48	0.98	0.64	0.50	1.27	1.53
Utilities	4.39	3.20	4.43	2.03	2.10	3.41	0.54	0.61	0.80	2.31	1.08	0.98
Wholesale trade	2.99	5.91	3.16	0.54	1.71	1.00	0.33	1.02	0.53	2.44	4.13	2.14
Retail trade	3.19	4.46	3.83	0.65	0.56	0.55	0.26	0.33	0.24	2.53	3.88	3.26
Transportation and warehousing	1.70	2.46	2.29	-0.54	0.88	0.19	0.26	1.02	0.34	2.25	1.56	2.09
Air transportation	4.14	7.19	9.35	0.19	3.10	1.64	0.47	2.81	1.25	3.95	3.96	7.60
Rail transportation	5.36	3.33	3.43	0.48	0.91	0.60	0.12	0.19	0.01	4.86	2.40	2.81
Water transportation	8.78	2.75	-4.62	-0.36	0.81	-0.49	0.29	1.53	0.89	9.18	1.92	-4.15
Truck transportation	2.64	0.06	1.00	-0.58	0.42	-0.38	0.18	0.46	0.22	3.24	-0.35	1.39
Transit and ground passenger transportation	-0.96	1.87	-1.48	-0.21	1.01	0.35	0.19	0.66	0.33	-0.75	0.85	-1.83

Appendix Table 2 (con't)

Sources of Growth in Value Added per Worker, 1987-2005

(average annual per cent or percentage point change)

				Contribution of:								
	Value added per worker			Capital per worker			IT capital per worker			Multifactor productivity		
Industry	1987-95	1995-00	2000-05	1987-95	1995-00	2000-05	1987-95	1995-00	2000-05	1987-95	1995-00	2000-05
Pipeline transportation	2.03	8.85	6.61	0.77	3.82	1.48	1.08	1.54	0.23	1.25	4.84	5.05
Other transportation and support activities	-2.50	2.31	1.41	-1.06	0.48	-0.22	0.32	1.10	0.14	-1.46	1.83	1.64
Warehousing and storage	1.63	3.48	2.85	-0.56	0.30	0.18	0.22	0.34	0.49	2.20	3.17	2.67
Information	3.45	2.53	9.62	1.53	1.87	2.74	1.15	2.32	2.01	1.89	0.65	6.69
Publishing and data prcessing	2.51	2.61	11.28	1.06	0.60	2.25	1.09	1.20	1.59	1.44	2.00	8.82
Motion picture and sound recording industries	-2.42	-1.56	4.68	0.51	-0.19	-0.65	0.46	-0.26	-0.17	-2.92	-1.37	5.37
Broadcasting and telecommunications	5.09	3.10	9.28	2.30	3.03	3.60	1.53	3.44	2.73	2.73	0.07	5.48
Finance and insurance	2.24	3.63	2.57	2.40	2.60	1.19	1.42	1.50	0.63	-0.15	1.01	1.36
Federal Reserve banks, credit intermediation, and related activities	0.98	-0.56	1.93	4.40	4.43	0.36	2.53	2.94	0.56	-3.28	-4.78	1.57
Securities, commodity contracts, and investments	7.84	20.30	8.48	0.31	0.18	-0.17	0.21	0.25	-0.15	7.51	20.08	8.67
Insurance carriers and related activities	2.13	-0.16	-0.02	2.39	1.68	1.30	1.40	0.83	0.81	-0.26	-1.80	-1.30
Funds, trusts, and other financial vehicles	-0.22	-14.65	6.18	-0.56	1.95	2.81	0.02	0.15	0.01	0.34	-16.28	3.28
Rental and leasing services and lessors of intangible assets	2.32	2.92	-1.66	2.70	10.87	5.66	1.73	5.72	2.26	-0.37	-7.17	-6.93
Professional and business services	-0.64	1.19	3.08	0.34	0.52	1.25	0.31	0.80	0.99	-0.97	0.67	1.81
Professional, scientific, and technical services	0.10	2.56	3.96	0.35	0.48	1.11	0.30	0.83	1.00	-0.26	2.07	2.82
Legal services	-0.50	0.30	1.78	0.08	0.13	0.22	0.04	0.15	0.17	-0.58	0.17	1.56
Computer systems design and related services	0.90	1.87	4.94	0.16	1.18	1.29	0.33	1.56	1.20	0.74	0.69	3.60
Miscellaneous professional, scientific, and technical services	0.19	3.37	4.51	0.45	0.34	1.41	0.37	0.80	1.28	-0.26	3.02	3.05
Management of companies and enterprises	-1.18	-1.68	1.88	0.37	0.32	1.29	0.34	0.37	1.07	-1.55	-1.99	0.58
Administrative and waste management services	-0.21	0.08	2.11	0.29	0.77	1.58	0.35	0.98	0.93	-0.50	-0.69	0.52
Administrative and support services	-0.12	0.09	2.21	0.33	0.97	1.68	0.34	1.07	0.99	-0.46	-0.88	0.52
Waste management and remediation services	0.41	1.74	0.29	0.70	-0.28	0.09	0.47	0.23	0.32	-0.30	2.02	0.20
Educational services, health care, and social assistance	-1.79	-1.20	0.97	0.41	0.12	0.39	0.44	0.31	0.51	-2.19	-1.31	0.58
Educational services	-0.79	-1.29	-0.21	0.10	0.31	0.44	0.13	0.28	0.27	-0.89	-1.60	-0.65
Health care and social assistance	-1.95	-1.13	1.10	0.41	0.13	0.38	0.45	0.33	0.54	-2.36	-1.26	0.72
Ambulatory health care services	-2.74	-0.83	1.58	0.12	-0.04	0.32	0.33	0.32	0.71	-2.86	-0.79	1.25
Hospitals and nursing and residential care facilities	-1.84	-1.53	-0.27	0.47	0.47	0.36	0.50	0.41	0.33	-2.30	-1.99	-0.63
Social assistance	0.31	0.60	2.96	-0.25	-0.31	0.08	0.13	0.18	0.11	0.55	0.91	2.88
Arts, entertainment, recreation, accommodation, and food services	-0.04	0.98	-0.14	0.17	0.15	0.16	0.14	0.20	0.15	-0.20	0.83	-0.29
Arts, entertainment, and recreation	1.77	1.25	-0.59	-0.06	1.15	0.71	0.02	0.16	0.15	1.83	0.09	-1.29
Performing arts, spectator sports, museums, and related activities	2.95	3.21	0.00	0.24	0.42	0.72	0.03	0.18	0.18	2.71	2.78	-0.71
Amusements, gambling, and recreation industries	0.57	-0.23	-1.01	-0.51	1.28	0.74	0.01	0.16	0.13	1.08	-1.49	-1.74
Accommodation and food services	-0.60	0.99	-0.03	0.21	0.73	0.22	0.10	0.13	0.16	-0.80	0.26	-0.25
Accommodation	0.81	0.09	-1.29	0.51	0.81	-0.33	0.11	0.11	0.11	0.30	-0.71	-0.96
Food services and drinking places	-1.13	1.43	0.65	0.13	0.66	0.55	0.10	0.15	0.19	-1.26	0.76	0.11
Other services, except government	0.76	-0.90	-0.41	0.52	-0.43	0.18	0.26	0.34	0.17	0.24	-0.48	-0.60

Lessons for Canada from International Productivity Experience

Andrew Sharpe[1]
Centre for the Study of Living Standards

ABSTRACT

The objective of this paper is to develop a more comprehensive understanding, from a policy perspective, of key drivers of labour productivity in selected OECD countries and their impact on enhanced productivity performance. The paper first presents some general lessons from the productivity performance of OECD countries and international evidence of productivity drivers based on the OECD growth project and productivity studies by the McKinsey Global Institute. It then briefly discusses the productivity experience of six OECD countries considered of particular interest to Canada — the United States, Australia, Ireland, the United Kingdom, Finland, and Sweden — and comments on possible lessons for Canada from these experiences.

THE OBJECTIVE OF THIS ARTICLE is to develop a more comprehensive understanding, from a policy perspective, of key drivers of labour productivity in selected OECD countries and their impact on enhanced productivity performance. It is hoped that the project will inform and strengthen future policy development in the productivity area.

The report is divided into three major parts. The first part compares Canada's productivity performance to that of other OECD countries. The second section presents some general lessons from the productivity performance of OECD countries and international evidence of productivity drivers based on the OECD growth project and productivity studies by the McKinsey Global Institute. The third part discusses the productivity experience of six OECD countries considered of particular interest to Canada — the United States, Australia, Ireland, the United Kingdom, Finland, and Sweden — and comments on possible lessons for Canada from these experiences.

Canada's Productivity Performance[2]

The Canadian economy has performed well on almost all indicators in recent years. Output and employment growth have been strong, inflation and unemployment are low, government deficits have long been eliminated, public debt is falling in both absolute terms and relative to GDP, and the Canadian dollar has appreciated. The one area where Canada has performed poorly is productivity growth. For the future advance in the living standards of Canadians,

1 The author is Executive Director at the Centre for the Study of Living Standards (CSLS). This is an abridged and updated version of a research report with the same title published by the CSLS in October 2006 (Sharpe, 2006). The report was prepared for the Labour Market Policy Directorate of Human Resources and Social Development Canada (HRSRC). The author would like to thank HRSDC officials, particularly Christina Caron, for comments.

2 The unabridged version of this report provides a detailed discussion of Canada's productivity performance as well as productivity growth rates and levels in OECD countries.

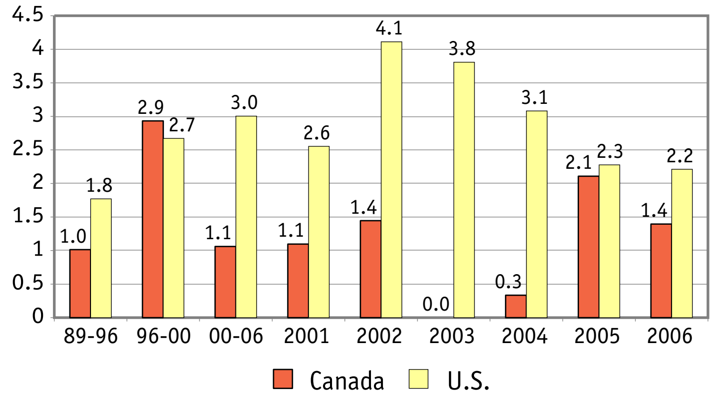
productivity growth is paramount, so this situation represents an important policy issue.

Canada's productivity growth record has been dismal, both from an historical and an international perspective. Since 2000, Canada's labour productivity performance has deteriorated relative to both our performance during the second half of the 1990s and relative to the performance of labour productivity in the United States in the 2000s. Business sector output per hour advanced at a 1.1 per cent average annual rate in Canada between 2000 and 2006, only about one third the annual rate of advance of 2.9 per cent recorded in Canada between 1996 and 2000 and only one third the annual rate of increase of 3.0 per cent recorded in the United States since 2000[3] (Chart 1). Canada's lagging labour productivity growth has resulted in the widening of the business sector labour productivity gap from 17 percentage points in 2000 (83 per cent of the US level) to 26 points in 2006 (74 per cent the US level).[4]

Canada's manufacturing productivity performance since 2000 has been even worse than the business sector performance. Output per hour advanced at only a 0.6 per cent average annual rate between 2000 and 2006, compared to 5.5 per cent per year in the United States (Chart 2). In other words, US manufacturing labour productivity growth has been nearly ten times as fast as that of Canada!

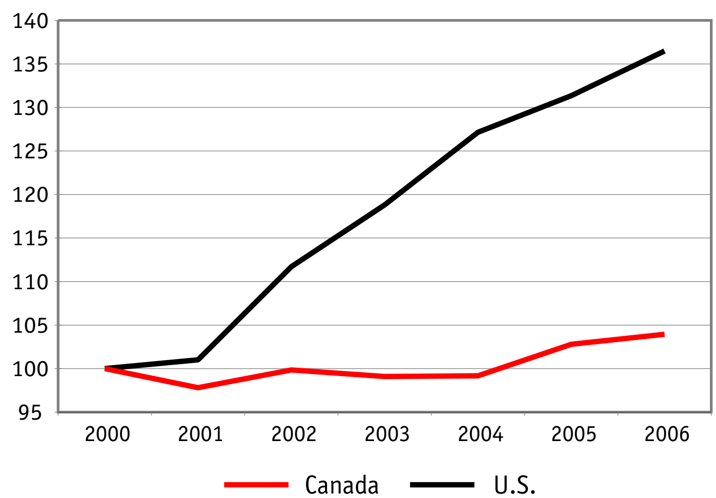
The causes of the fall-off in labour productivity growth in Canada after 2000 are still poorly understood. Possible explanations include measurement problems; weak productivity growth in resources industries exploiting poorer quality resources such as the oil sands; weak ICT investment; a failure to exploit advanced technologies; and weak wage growth leading to a slower rate of substitution of capital for labour (Rao, Sharpe and Smith, 2005).

Chart 1
Business Sector Output per Hour Growth in Canada and the United States
(average annual rates and annual rates of change, per cent)



Sources: GDP in chained dollars and total hours worked from the Productivity and Costs Program of the Bureau of Labor Statistics for the United States, and the Productivity Program Database of Statistics Canada for Canada.

Chart 2
Output per Hour in Manufacturing, Canada and United States, 2000-2006
(2000=100)



Source: Statistics Canada and BLS.

From an international perspective, Canada's relative productivity performance has been very weak. Over the 1973-2006 period, output per

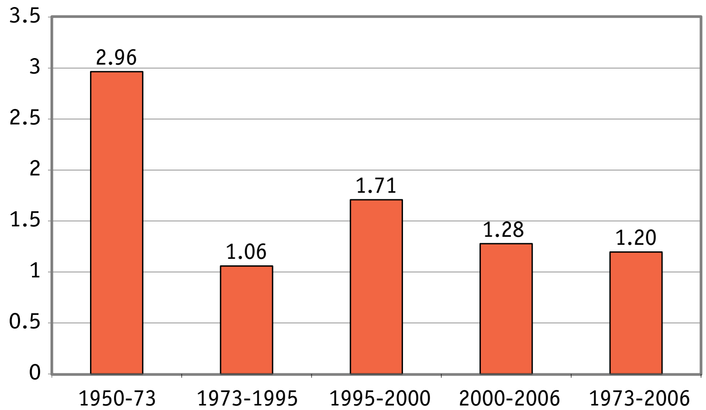
3 Total economy productivity growth exhibited an almost identical pattern.

4 This figure is based on Industry Canada benchmark labour productivity level estimates for 2002 (Rao, Tang and Wang, 2004) and productivity growth rates after 2002.

Chart 3

Total Economy Output per Hour in Canada, 1950-2006

(average annual rates of change, per cent)



Source: Groningen Growth and Development Centre and the Conference Board, Total Economy Database, February 2007, http://www.ggdc.net.

hour in Canada advanced at only a 1.2 per cent average annual rate (Chart 3), down from 3.0 per cent in the 1950-73 period, a drop of nearly two thirds. Since 1973 Canada has had the third lowest rate of growth in output per hour among 23 OECD countries, with only New Zealand and Switzerland doing worse (Appendix Table 1). This resulted in Canada's level of output per hour falling from third highest in the OECD in 1950 and in 1973 to 16^{th} in 2006 .

Reviving productivity growth represents the biggest economic challenge facing this country. Lessons from international productivity experience may be useful for the development of effective policies to meet this challenge.

General Lessons from OECD Productivity Experience

OECD Growth Project

The OECD growth project (OECD 2003, 2004b) analyzed the sources of economic growth based upon aggregate data and using cross-country regression analysis, with a particular emphasis on the ways in which policies affect outcomes. It is argued that the causal variables looked at are able to explain much of the observed growth differences over time and across countries. It was found that investment in physical and in human capital was important to growth; that sound macro policies yield higher growth; and that the overall size of government in the economy may hinder growth if it becomes too large, although the pattern was mixed. Some government spending was found conducive to growth, while high levels of direct taxation (taxes on wages and profits) discouraged growth. R&D activities by the business sector had high social returns, and hence contributed to growth, but there was no evidence in this analysis of positive effects from government R&D. The study found some evidence that financial markets are important to growth, through helping to channel resources towards the most rewarding activities and through encouraging investment.

A very interesting and surprising result is that "exposure to international trade" is an important determinant of output per working age person. The analysis concludes that an increase of 10 percentage points in trade exposure (an adjusted average of exports and imports as percentages of GDP) raises output per person by 4 percentage points. This result, if taken at face value, gives strong support to the view that increased globalization improves economic performance. It suggests that all OECD countries should move aggressively to remove remaining barriers to trade, and do so for their own advantage.

Human resources and skills development issues related to productivity also receive particular emphasis. For example, the OECD has found that policies of certain countries to re-integrate low-skilled workers, while resulting in a widening of the employment base and increased potential growth, temporarily depressed productivity growth through a negative composition effect on labour quality.

In summary, the OECD identified at the macro level education, innovation, deregulation and investment as the basic determinants of productivity growth. It also identified inflation, fiscal policy, international trade, and the financial system as policy and institutional determinants of growth. At the industry and firm level, the OECD has identified market conditions, competition, and innovation and R&D as key productivity drivers.

McKinsey Global Institute Productivity Studies

The McKinsey Global Institute (MGI) is a think tank based in Washington, D.C. founded in 1990 by McKinsey & Company with the objective of analyzing international productivity levels from both economic and management perspectives. Over the last fifteen years, MGI has studied most of the world's major economies. In each case, MGI uses microeconomic analysis on a sector-by-sector level to study the effects that industry decisions ultimately have on national productivity. This section synthesizes some of these findings to see what potential lessons can be drawn regarding productivity level differences between Canada and other countries.

Time and again, the McKinsey Global Institute's studies have returned to the same story in trying to explain productivity gaps between countries: a lack of competitive intensity. To the extent that certain European and Japanese sectors seem to consistently trail the United States in productivity, these sectors are nearly always characterized by a small number of domestic firms who engage in little price or service competition because of regulatory protection in the form of product market restrictions and trade barriers. MGI finds that such restrictions lead to managerial complacency, a consequent lack of innovation in production processes, and ultimately to a productivity performance below that of the technological leader. Potential factors related to competition that have been identified by MGI as directly affecting productivity are the following.

- **Concentration:** A high market share held by a small number of firms is not necessarily inconsistent with intense competition. Concentration can improve productivity through achieving economies of scale, and it can also boost productivity if it allows a small number of large firms to compete intensely with each other. Examples of highly concentrated yet highly competitive industries include the Dutch banking industry and the Swedish automobile industry.
- **Trade Protection:** Tariffs and quotas reduce productivity through shielding industries from international competition, making the adoption of global best practices unnecessary. The automobile industry in Germany, France and the United Kingdom, the food processing industry in Japan, and many Swedish service industries are all examples highlighted by MGI of industries whose productivity performance has been hindered by trade protection.
- **Deregulation:** MGI highlights the airline, telecommunications and banking industries as cases in which deregulation has boosted productivity, and in which countries that have chosen to delay or forgo deregulation have consequently suffered lower productivity levels than the early deregulators.

Other competition-related factors can affect productivity in a more indirect fashion.

- **Minimum Wages:** Higher wages typically have the effect of reducing the number of low-skill jobs, as the benefit of these low-skill services is outweighed by the higher cost of providing them. While this has the effect of raising conventionally-measured average labour productivity, MGI argues that overall "service productivity" is negatively affected because the range of services that is offered shrinks.

- **Work Rules:** MGI recognizes that some labour market inflexibilities can be beneficial. However, collective agreement terms that are not adjustable to market realities can negatively affect productivity by preventing productivity-enhancing reorganizations of work.
- **Zoning Laws:** Some European countries have zoning regulations that have a negative impact on productivity by making it difficult for firms to purchase parcels of land of a required size, and by creating an artificial scarcity of land and thereby making land overly expensive. This affects productivity because high rents hinder the ability of smaller firms to innovate, and because larger firms have difficulties achieving optimal scale.

Perhaps even more important than the market conditions under which a firm operates is the way managers choose to react to those conditions. Competitiveness is the main driver of managerial innovation, but that managerial innovation (or lack thereof) is what affects productivity, first at the firm level, then the industry level, and ultimately at the national level. MGI makes the following observations related to managerial innovation.

- **Best Practice:** Managers need to be aware of best practices in a given industry, and be prepared to implement them. MGI states that sufficient exposure to competition will ensure that this is the case.
- **Human Capital:** MGI finds little evidence that labour skills at the production level differ greatly across countries. However, the qualifications of managers can have a significant impact on productivity, through entrepreneurship and the training of production workers.
- **Marketing:** MGI finds that the U.S. telecommunications sector's productivity performance has been positively affected through marketing, since the resulting greater demand for telecommunication services means that there is greater output for a given investment in fixed capital.
- **Information Technology:** Although few would dispute that investment in information technology can have a significant impact on productivity growth, MGI concludes that realizing its full benefit requires an appropriate application. In addition to the effect of IT use on productivity growth, the presence and strong productivity performance of industries producing IT goods also positively affect overall manufacturing productivity growth.
- **Capital Intensity:** MGI finds that improvements in capital intensity are a necessary but not sufficient condition for improvements in productivity. This is because increasing the amount of capital per worker does not necessarily mean that the capital is being used efficiently. Improvements in capital productivity are often dependent on other managerial and competitive factors.

The McKinsey Global Institute has not produced a report on Canadian productivity. However, the findings from the McKinsey productivity studies on industry productivity differentials between the United States and a number of major developed and developing countries may have relevance for the explanation of industry productivity differentials between the United States and Canada. In some respects, the Canadian economy is a bit of a hybrid between the U.S. free-market system and the more sheltered, socially-conscious systems of countries like France or Sweden. Canada is more globally-exposed than most EU countries, yet it also retains a certain level of trade protection and restricts entry to some domestic sectors. It also has a more developed welfare state than the United States in terms of more government control of social programs such as health care and pensions.

Lessons from Country-Specific Productivity Experience

United States

The United States has seen remarkable labour productivity growth since 1995.[5] Given the similarities between Canada and the United States, the productivity experience of the United States, and in particular the reasons for that country's superior productivity growth, are very relevant to Canada.

A key development in the United States has been the massive introduction of information and communication technologies (ICT) into the workplace, which have revolutionized production processes and supply-chain management. Many believe that this development has ushered in a "new economy" characterized by large technology-driven productivity gains. A large literature has developed around this question of a new economy. The generally accepted conclusion seems to be that information and communications technologies (ICT) were indeed responsible for much of the post-1995 labour productivity growth acceleration in the United States through economy-wide ICT capital deepening, MFP growth among ICT users, and MFP growth of ICT-producing industries.[6]

However, this is not an entirely satisfying explanation of the U.S. labour productivity growth acceleration, because it leaves the sources of the ICT revolution unaddressed. Veugelers (2005) identifies the US university system as probably the most important factor that facilitated the take-off of ICT production and use. The combination of competition between private and public universities with the system of peer-reviewed research grants ensures that the best students are attracted to the United States, and consequently that the United States is always a world leader in research. More importantly, the world-class research produced by U.S. universities gives a strong incentive for linkages to form between the higher education sector and private businesses in terms of commercializing this knowledge.

Other aspects mentioned by Veugelers as driving the ICT revolution include strong intellectual property rights; flexible labour markets in terms of both international and internal migration of highly skilled workers; a large and unified market that is mostly free of barriers related to language, customs and standards; and well-developed and flexible financial markets.[7] This latter factor is especially important in terms of providing entrepreneurs and innovating firms with access to venture capital and other sources of finance. Above all, intense product market competition, embodying traditionally strict laws against anti-competitive practices, ensures that the most innovative firms are able to grow quickly and thereby challenge less innovative firms to improve their performance or exit the market. Such competitive intensity would appear to be crucial in motivating the diffusion of ICT, as industries protected from com-

5 Furthermore, it is now widely accepted that, in addition to the original acceleration in labour productivity growth in 1995-2000 relative to 1973-1995, the United States has experienced an additional post-2000 labour productivity growth acceleration. Labour productivity growth decelerated in 2005 and 2006, but is still advancing at around a respectable 2 per cent per year.

6 There is a large literature on this issue. See Bosworth and Triplett (2007) in this issue for a recent contribution. Also see Gordon (2000), Jorgenson, Ho, and Stiroh (2002), Oliner and Sichel (2000 and 2002), Rao and Tang (2001), and Stiroh (2001).

7 To all of these factors behind the U.S. ICT revolution might be added the large U.S. government expenditures over the past several decades associated with national defence and space research. While much of this expenditure was motivated by the Cold War or simply the protection of such a large homeland, it fostered much cutting edge research. For example, the method used to send data over the internet was pioneered in response to government funding to establish an emergency communication system. Research originally directed towards space or defence applications in many cases proved useful and groundbreaking in other contexts or provided essential knowledge for progress in other fields of research.

petition would find the reductions in costs and enhancements to efficiency afforded by ICT less necessary.

Since 2000, ICT investment has fallen off in the United States, but labour productivity growth has accelerated. One possible explanation for this development is that the effectiveness with which ICT is used has continued to increase, so that the overall productivity-enhancing effect of ICT is only realized with a lag. Organizational practices and production processes have been modified in response to ICT. Productivity growth may also have been facilitated by increased workplace training that gave workers the skills needed to maximize the potential of ICT.

In short, the United States economy possesses just about all of the virtues that are typically associated with improving productivity growth. In this sense, there is much to learn from the U.S. experience, although questions remain. First, how did these numerous factors come precisely together to create the phenomenal productivity success since the mid-1990s? Second, could these factors produce such productivity success if transplanted to other countries?

While much research still remains to be done on these questions, it is possible that the intense competition and strong market forces present in the United States have been responsible for, or have at least played a major facilitating role, in the development of the many factors that have proven crucial for the U.S. productivity growth resurgence. Such competition attracts the brightest talent to the country, gives a strong incentive to commercialize the knowledge produced by that talent, and ensures a large market for such successful innovations as firms adopt them as part of their comprehensive and ongoing efficiency improvement efforts. However, while competition may have been the integral ingredient bringing all of these positive factors together in the United States, it is unclear whether such an ingredient exists that would ensure success in Canada and other countries.

Ireland

Output per hour growth in Ireland has averaged 4.1 per cent per year since 1973 (Appendix Table 1). This was the second fastest (after Korea) productivity growth rate experienced among OECD countries over the period. The level of output per hour in Ireland in 2006 exceeded that of most other industrial countries, and is beginning to challenge U.S. productivity levels.[8]

Rapid Irish productivity growth was not driven by only one single factor. According to Cassidy (2004), the main drivers behind the fast productivity growth were: (1) the substantial foreign direct investment inflows from the United States; (2) the continuing shift of economic activity and employment from the primary sector to the secondary and tertiary sectors, especially the high-technology sectors including the chemical and the ICT sectors; (3) the availability of a young, relatively well-educated workforce; and (4) the increased European integration and increased subsidies from the European Union.

Economists believe that economic policy can have a central role in determining the productivity potential of an economy. This is especially true when we review Irish policy development as Irish public policy has been very active in promoting economic growth since the 1950s. Its main strategy has three components:

- promote free trade and monetary integration;
- develop a regulatory environment favourable to business and entrepreneurship; and
- provide free secondary and post-secondary education.[9]

In sum, Irish commercial, industrial, tax and education policies have been very supportive of

8 See Fortin (2001) have a discussion of the Irish economy in the 1990s and lessons for Canada.

the rapid pace of long-term productivity growth. This strong and consistent support is not recent, but began to develop in the 1950s and matured in the 1970s. The goals of these policies included but were not limited to the promotion of greater openness to foreign trade and investment, the development of a business-friendly environment, and the provision of a highly skilled labour force. The right policies eventually paid off.

Australia

Australia and Canada are very similar. They both are relatively small economies and have similar economic structures. During the 1990s, Australia was an outstanding economic performer among leading economic nations in the world. Its real growth per capita averaged above 4 per cent per year, outperforming Canada, and this was driven by significant advances in productivity (Appendix Table 1).

Australia's ability to grow so strongly, even in the midst of economic challenges such as the Asian financial crisis, has led some to label Australia as the "miracle" economy. However, according to Parham (2002), this was no miracle. The productivity surge was certainly remarkable, but it was also "predictable."

There are several drivers of this success behind Australia's outstanding economic performance. Gans and Stern (2003) point out that relative macroeconomic stability and a substantial modernization of the tax system contributed to this substantial level of achievement. However, the policy reform in Australia that has "fostered a transition to more competitive, open, flexible, innovative and resilient economy" has been particularly important to promote productivity growth (Parham, 2004). Parham points out that the approach of the reforms was not to attempt to raise productivity growth via a targeted or industry-specific strategy. Rather, the approach was largely to release the shackles that had previously restricted productivity growth and to pursue social objectives through more targeted and less distortionary instruments.

The policy reforms mainly included but were not limited to: deregulation of access to finance; floating the currency; marked reductions in barriers to trade and foreign direct investment; commercialization (and some privatization) of government business enterprises; strengthening competition policy; enhancement of public utilities in key infrastructure areas such as telecommunications and energy; and enabling greater labour market flexibility.

Australia began to introduce these reforms in the mid-1980s and continued to apply them throughout the 1990s. But according to the McKinsey Global Institute's evaluation in 1995 (MGI, 1995b), Australia's economic reforms did little to improve its relative performance at that time. However, the post-1995 period saw Australia begin to enjoy a faster rate of growth in productivity.

Among those drivers that promote Australia's efficiency gains, three policy-related factors have been given particular attention.

- Sharper competition — through lower trade and foreign investment barriers and domestic deregulation and pro-competition regulation —"has provided greater incentives for business to improve productivity by seeking out more value-adding products and new markets and by reducing costs" (Parham, 2002). The reform of public sector services has improved efficiency and has especially benefited businesses.
- The promotion of innovation — through encouraging rigorous domestic competition and establishing strong protection of intellectual property — has transformed Australia from an adopter to a producer of global

9 The unabridged version of the paper reviews in detail Ireland's policy strategy in such key areas as commercial policy, tax policy, industrial policy, innovation policy, and education policy.

technology. The development of a national innovation system, which includes a common innovation infrastructure, the cluster-specific environment and the quality of linkages (Gans and Stern, 2003), has strengthened Australia's innovative capacity and stimulated the development even of traditional industries such as wine and agriculture.

- Businesses are able to adjust production and distribution processes more flexibly, due to a newly-established ability to negotiate work arrangements at the enterprise level, rather than relying on arrangements imposed through centralized "one-size-fits-all" bargaining. The greater flexibility in the labour market has provided the workforce with a greater incentive to invest in education and training, which in turn has influenced productivity growth positively. The greater openness accompanied with greater flexibility has encouraged greater specialization and has provided easier access to up-to-date technology and know-how.[10]

In summary, Australia experienced a resurgence of productivity growth in the 1990s. The fact that most other OECD countries did not share this experience suggests that domestic factors must have played an important role in this resurgence. According to the studies reviewed above, policy reforms that were introduced in the mid 1980s have been major drivers and enablers of Australia's impressive productivity performance. Policy reforms have enhanced competitive pressures; opened the economy to trade, investment and technology; raised investment in R&D; and encouraged firms to become more flexible in terms of adjusting all aspects of production, distribution and marketing. On top of these foundations, the widespread use of ICT, the increased labour market flexibility and the strengthened national innovative capacity have been specific factors driving the remarkable productivity growth.

United Kingdom

The United Kingdom in 2006 had a labour productivity level above that of Canada, reflecting the fact that its labour productivity growth over the 1973-2006 period was double that of Canada (Appendix Table 1). The UK has undergone a number of market-oriented reforms that may have relevance for Canada.

Before 1979, labour productivity growth in the UK was one per cent per year slower than that for Germany or France. The timing of the disappearance of this growth rate differential after 1979 coincides with the economic reforms enacted by the Conservative government under Margaret Thatcher's leadership. These reforms sought to reduce government intervention in labour and product markets and increase the efficiency with which they operated, two measures that fostered productivity gains observed over the next two decades (Card and Freeman, 2002). Evidence of the market-oriented nature of these reforms comes from the change in UK's ranking with respect to measures of competitiveness and "market friendliness". In the late 1970s, several of these indices ranked the UK in the middle of a group of Western economies. By the late 1990s, the UK stood at or near to the top of several of these indices and in some cases ranked ahead of the US. Thus, economic reforms in the UK over the past 20 years appear to have yielded benefits in the form of higher productivity growth and halted the relative decline in living standards, at least with respect to France and Germany.

What UK policy reforms helped to halt the relative decline in labour productivity and raise its growth rate? Card and Freeman (2002:48) identify three reforms in particular that have

10 The unabridged version of this paper provides a discussion of Australia's experience with ICT, its labour market, and the innovation system.

promoted growth in labour productivity over the past two decades.

- Reductions in trade union power. This has increased labour market flexibility, promoted competition among workers and made it easier to implement and reform labour market regulation. These policies also successfully increased the freedom of business to manage its workplace. Each of these measures has growth promoting effects.
- Privatization of state-owned industries. Privatization has raised labour productivity of the UK economy as a whole as industries and firms were made more responsive to market conditions and shed excess labour.
- Creation of incentives for self-employment and share ownership of firms. The creation of share ownership plans aligned the incentives of the firm with that of the workers. Workers now had a direct stake in the success of their firms which has a direct consequence of their productivity.[11]

Despite the pick-up of productivity growth, the UK productivity level still remains well behind that of many other OECD countries. The definitive reason for why the UK has lagged behind its international competitors remains elusive. In reality, the explanation is likely to consist of a set of factors. Three factors in particular have been identified by those who have studied the gap.

- Under-investment in education. The failure to provide sufficient numbers of well-educated and highly skilled workers to industries has limited the development of the UK economy's capacity to innovate. In turn, this has reduced the potential for productivity growth.
- Low rate of ICT diffusion. Low rates of ICT usage has led to reduced opportunities for firms and organizations to compete with their international counterparts through cutting prices or providing fast and efficient service. This has exacerbated the UK's "skill shortage".
- Excessive government regulation. Despite earlier efforts at reform, regulations still prevent labour and goods markets from being truly competitive. There still exist barriers to entry or expansion by best-practice operators. These barriers also hinder the adoption of best-practice techniques and reduce the competitive pressure on industry participants to raise their productivity.[12]

Finland

Finland, a small country of five million people located far from the centre of Europe, has enjoyed great economic success in recent years. According to the OECD (2004a), the transformation of the Finnish economy over the last decade has been one of the few examples of the "new economy" taking hold in Europe. Labour productivity growth since 1973 at 2.8 per cent per year was among the highest in the OECD (Appendix Table 1).

Finland is not only one of the EU leading producers of ICT (together with Ireland and Sweden), but also a prominent example of leapfrogging with respect to the rest of the OECD. Among OECD countries, it has made the most progress in the world ranking of IT producers since the early 1990s.

Finland since 1990 has gone from being a net importer to a net exporter of high-tech goods. Indeed, Finland has the largest per capita surplus in foreign trade in communications equipment in the world. The Finnish ICT sector accounted for 15 per cent of the value of market production (10 per cent of GDP) in 2001, up from 8.0 per cent in 1995, 5.8 per cent in 1990, and 3.7 per cent in 1975.

11 The unabridged version of the paper discusses how these three reforms contributed to productivity growth.

12 The unabridged version of the paper discusses how these three factors account for the productivity gap.

Nokia is the leading Finnish company accounting for about one half of the overall IT contribution to aggregate value added, and 3.3 per cent of GDP. The firm accounts for one fourth of Finnish exports, one third of business R&D, and 5 per cent of manufacturing employment. Perhaps surprisingly, Nokia was until 1990 a conglomerate with many business lines. The deep recession of the early 1990s propelled the firm's leadership to re-orient toward electronics and drop other activities, with cell phones becoming the dominant product line. Nokia's success has attracted much international venture capital to Finland in search of the "next Nokia."

The reasons why Finland has been so successful in exploiting new globally available technologies are still poorly understood. Lane (2004) has suggested the following factors:

- a university education system heavily oriented toward science and technology;
- high levels of R&D undertaken by both the business and non-business sectors;
- a focus on all aspects of IT products, with world leadership in both goods (Nokia cellphones) and services (Linux software);
- the early liberalization of the telcom sector;
- an historical lack of monopolization of the Finnish telephone network by the State, ensuring that competitive pressures to invest in R&D existed even before deregulation; and
- the liberalization of the financial sector, leading to better access to capital for IT start-ups.

Finland experienced a severe recession in the early 1990s, with output falling steeply between 1990 and 1992 and with unemployment rising to nearly 20 per cent. The causes of this recession included the abrupt loss of the Russian market linked to the collapse of the USSR, recession in other EU countries, the overheating of the Finnish economy in the late 1980s, a credit and banking crisis, and inappropriate policy response to deal with the financial crisis.

The crisis appears to have had a transformative effect on Finland, with a dynamic market economy emerging out of a highly regulated one. According to Daveri and Silva (2004:129), two changes arising from the recession were critical from the point of view of productivity: markets took over from the State in allocating resources and the stock market took over from the banks in the allocation of credit. Capital was now used more efficiently, and many firms actually shed capital, resulting in a drop in the capital-labour ratio and considerably higher total factor productivity in certain sectors (Maliranta, 2001).

Nokia, the world leader in cellular phone production, directly and substantially contributed to enhanced productivity growth in the Finnish ICT sector. However, productivity gains outside Nokia and a few other IT-related service industries have been small, temporary or short-lived, or non-existent. Daveri and Silva (2004) find that not only has the scope of productivity gains been narrow in Finland, but what has been observed cannot be clearly ascribed to the technological champion in that country. The authors consequently conclude (page 123) that "...even in a country endowed with a world-class national champion, the 'new economy' takes a long time to show up. And in contradiction to commonly held tenets in public debates, IT diffusion has shown a limited potential in speeding up this process in Finland."

The Finnish labour market has many of the characteristics of the Nordic model which some economists believe hinders productivity growth. Taxes on labour are high, wage differentials between low and high skilled workers are low, social benefits are generous, input from the labour market or social partners (i.e. business and labour) is highly valued, and collective bargaining is centralized. These features do not appear to have seriously impeded (and may have even facilitated) Finland becoming an IT leader.

At least three major lessons can be gleaned from the Finnish productivity experience. First, a vibrant high-productivity growth ICT-producing sector does not necessarily diffuse robust productivity gains to non-ICT producing sectors, especially in a small open economy. Second, an above average performance on innovation indicators such as R&D does not necessarily translate into above average living standards. GDP per capita in Finland is still only close to the OECD median country despite its innovative economy. Third, robust productivity growth across all sectors requires adaptable labour market institutions, and innovative financial markets, and a workforce well trained in science and technology. The availability and diffusion of best practice technologies is a necessary condition, but by no means a sufficient condition for productivity advance.

Sweden

Sweden's labour productivity growth experience in the 1980s and especially the 1990s provides an interesting perspective on the factors associated with a successful productivity performance. The Swedish manufacturing sector achieved world-class productivity growth in the 1990s, while the service sector, accounting for a much larger share of the economy, saw much slower labour productivity growth and little or no improvement in this regard relative to the 1980s. This extremely asymmetrical performance affords the opportunity to attempt to identify both the factors behind the manufacturing sector's success and the factors behind the rest of the economy's less impressive performance.

Two comprehensive studies of the Swedish economy — one by the McKinsey Global Institute (1995a) and the other a recent country survey by the OECD (2004c) — identify competition as a source of both the manufacturing sector's rapid productivity growth and the poorer growth of service industries.[13]

While Sweden's productivity performance in the 1980s and 1990s is interesting in its own right, the lessons to be drawn for other countries are not immediately obvious, given the relatively unique characteristics of Sweden such as a single dominant industry, a high degree of income redistribution and significant employment protection even by European standards, and the polarization of its economy into some highly competitive sectors and other heavily protected sectors. Nonetheless, some general points can be made.

- A comprehensive approach to promoting competition — encompassing deregulation and product market competition, the free movement of labour and capital, openness to trade, among other factors — is necessary for maximizing the potential for productivity gains.
- The reliance on a single industry or even firm for aggregate productivity increases can subject a country to the greater possibility of suffering a prolonged stagnation in labour productivity and hence living standards. Indeed, the present slowdown in the telecommunications industry internationally will probably mean that Sweden's aggregate labour productivity growth will fall far below the impressive rate experienced in the 1990s.
- As in Finland, the productivity-enhancing ICT revolution in Sweden is linked almost exclusively to ICT production rather than ICT use, and is dependent on a single firm. It is therefore not yet possible to state that Sweden has entered a "new economy" phase of development, defined as an acceleration in labour productivity growth that is broadly based across industries. This may in turn imply that the new economy-style produc-

13 See the unabridged version of the paper for a discussion of these two studies.

tivity growth at the aggregate level experienced by Sweden in the 1990s may not be sustainable.

- In a small open economy such as Sweden or Finland, most technological spill-overs occur across international boundaries, and there appears to be very limited scope for other industries and firms to benefit from the R&D and productivity performance of the national leaders. This underlines the importance of openness for innovation and productivity growth.

Lessons for Canada from International Productivity Experience

Four important lessons for Canada emerge from this review of the productivity experiences of the six OECD countries in this article. They are highlighted below.

- Competition and productivity are closely intertwined. Sectors that have been opened up to market forces, both domestic and international, have generally registered significant productivity gains, as seen most strikingly in the United Kingdom. The existence of a competitive environment is an essential condition for productivity advance. One of the most important steps, if not the most important step, that governments can take to promote productivity growth is to ensure that markets, whether it be product markets, labour markets, or capital markets, are as competitive as possible.
- Human capital is the foundation of productivity advance, driving innovation. Countries that have focused on human capital investment, particularly in the higher education area, have seen a major payoff in productivity growth. The basis of the U.S. productivity resurgence is that country's world class system of research universities, which have created the knowledge that led to the emergence of productivity-enhancing ICT. Ireland's productivity success is also closely linked to the massive expansion of opportunities for higher education in that country. Thus support of the higher education sector, including both research and teaching, likely represents the most effective means by which government resources can be used to promote productivity growth.
- R&D intensity (R&D/GDP) is crucial for innovation and productivity growth, but it is not the complete story. The strong productivity performance of Sweden and Finland is closely related to the rapid growth in these countries of ICT-producing industries, in turn related to high R&D intensity. But the Swedish and Finnish experiences have shown that the presence of highly successful firms in certain high tech industries in a country does not automatically lead to the diffusion of productivity-enhancing ICT to the non-ICT producing sectors. Rather, it is the overall openness of these sectors to world technological developments that is crucial for their adoption of leading technologies. Since Canada through its R&D efforts accounts for a very small proportion of the world supply of innovations, the wide diffusion of best practice techniques in this country depends critically on the ability of Canadian firms to keep themselves abreast of world technological developments and to assimilate those developments. As the Swedish and Finnish cases illustrate so well, R&D intensity in itself may be necessary for rapid productivity growth, but it is certainly not sufficient. Sweden and Finland have the two highest R&D intensities, yet have labour productivity levels below the United States and at least eight other European countries.
- As a general rule, institutional rigidities impede productivity advance while institutional flexibility supports it. Many examples

of this general principle came to light in the six country studies. For example, both Sweden and Finland have recognized that certain of the characteristics of their labour market institutions — such as centralized collective bargaining and limited earnings differentials between high and low skilled workers — can have negative implications for productivity growth. Both countries have shown flexibility in adapting their institutions to make them conducive to, or at least not inimical to, productivity advance.

Based on the four key lessons for Canada highlighted above, a number of specific policies that could be usefully considered in the Canadian context are outlined below.

In terms of the first lesson concerning the importance of market forces, some specific policies that could foster productivity growth in Canada are the following.

- An enhanced competitive environment through deregulation. A step in this direction for the telecommunications industry was recently recommended in the recently released final report of the Telecommunications Policy Review Panel (2006). Such a move would foster faster adoption of information and communications technologies (ICTs) through greater ICT investment, an area where Canada significantly lags behind the United States (Sharpe, 2005). ICT have been identified as a key source of productivity growth and responsible for the acceleration of productivity growth in both Canada and the United States in the second half of the 1990s.
- A gradual winding down of marketing boards which limit the supply of certain agricultural products such as milk. Such a measure would spur the entry of producers with innovative ideas and the exit of low productivity firms, thereby increasing productivity through a composition effect. As these industries affected by production restrictions are relatively small, this measure would likely not have a major impact on productivity. There would likely be strong opposition to such a move as the benefits of marketing boards are concentrated in the hands of a small number of producers, but the costs are borne by all the population through higher prices. The producers have much more incentive to organize against such a policy than the beneficiaries to organize in favour of it.

In terms of the second lesson, the federal government has recognized the importance of human capital for productivity growth. Since 1997, the federal government has taken a number of measures to boost post-secondary education, including the establishment of the Canada Research Chair program and additional funding for the granting councils. Two policies in the human capital area that could be pursued more vigorously are outlined below.

- A reduction in the underemployment of the human capital of recent immigrants to Canada through programs that better and more quickly foster the integration of immigrants into the workforce. Such programs would include language training, subsidies for employers to provide recent immigrants with Canadian work experience, and different types of integrative assistance (e.g. information on Canadian requirements in licensed occupations, individual counseling for the development of plans for recent immigrants to find appropriate employment, retraining programs to meet Canadian requirements, seminars on job search skills in the Canadian context, etc.) to immigrants so that they can meet Canadian occupational requirements, both before and after arrival in Canada. The boost to productivity growth from such measures is potentially huge. The skills of immigrants have already been acquired at no cost to Canadian taxpayers. With a small investment in workplace integration, the skills of these immigrants could become fully utilized and contribute significantly to the economy.

- A greater emphasis on the basic skills of the workforce. A characteristic of the workforce of a number of the countries studied in this report (e.g. Sweden, Finland, Ireland) was its high level of basic skills. Indeed, it has been shown that improvements in basic skills such as literacy and numeracy can significantly boost productivity growth (Coulombe, Tremblay, and Marchand, 2004). There is much room for Canada to improve the basic skills of its workforce. Policies in this area, such as basic literacy programs, would potentially have a large payoff (Fortin, 2005). One specific program is to extend Employment Insurance (EI) benefits to low skill workers who take education or training leaves as part of a formal training plan (Jackson, 2005).

The third lesson concerns the importance of the adoption of new technologies, as opposed to the creation of new technologies through R&D. This lesson was in particular identified with Ireland, a country with a relatively low R&D intensity, yet very rapid productivity growth. Specific policies that could be considered in this area for Canada include the following.

- The expansion of programs that foster the adoption of best practice technologies and management practices by small and medium-sized enterprises (SMEs) by providing these firms with information on the latest technological developments in their industry and with technical advice on how to best adopt the latest technology in their situation. The Industrial Research Assistance Program (IRAP) run by the National Research Council is an example of a program that has been recognized as effective in fostering the adoption of new technologies by SMEs. The expansion of IRAP and similar technology transfer programs would likely have a significant productivity payoff.
- As noted earlier, information and communications technologies are a key driver of productivity growth. Yet Canada badly lags the United States in ICT investment per worker across almost all industries. Measures to increase ICT investment thus could boost productivity growth. One such measure is the ICT tax credit recently proposed by the Telecommunications Policy Review Panel (2006). This measure would be targeted at SMEs and would apply on an incremental basis to all expenditures on ICT capital goods as well as complementary investments in training and reengineering needed for effective ICT adoption. A second measure is the harmonization of provincial sales tax systems with the GST. The PST in certain provinces (Ontario, British Columbia, Manitoba, Saskatchewan, and Prince Edward Island) is applied to ICT spending, increasing its cost compared to other more long-lived asset types, and discouraging ICT investment. Harmonization with the GST (under which ICT investment is not taxed) would reduce this current bias of the tax system against ICT investment.

The fourth lesson concerns the role of institutional rigidities in impeding productivity growth and the identification of these rigidities and their removal. Specific rigidities in Canada include the following.

- The Employment Insurance (EI) program, which provides income support for the unemployed in seasonal occupations, discourages to some degree mobility to regions where permanent employment prospects are more promising. Given the recent increase in interprovincial mobility in this country from high unemployment to low unemployment regions (the population of Newfoundland fell from 580 thousand in 1992 to 520 thousand in 2003, with many of the out-migrants going to Alberta), it is important not to overemphasize the importance of this rigidity to mobility. Nevertheless, during this time of very low national unemployment, from a national perspective there is no better occasion to encourage the unemployed to leave high unemployment areas to seek work through a shift from a passive income support role of EI to a more active role for EI that attempts to integrate the unemployed into jobs by fostering mobility and retraining.

- Reduction in interprovincial barriers to labour mobility in the professions and the trades to allow a greater role for market forces to influence the reallocation of workers from low productivity/low wage to high productivity/high wage jobs, an important source of productivity growth. Jurisdiction over occupational certification resides with the provincial level of government. It is essential that the federal government work with the provinces to develop certification programs that are recognized in all provinces. The Red Seal program for the apprenticeable trades is an excellent example of a program that promotes mobility throughout the country. This program, and similar programs for other occupations, should be expanded.

Conclusion

This report has surveyed the international productivity experience of six OECD countries and drawn out lessons for Canada. While there is much to learn from international experience, it is important to recognize that policies that work in one country flow from the particular context or situation of that country and are likely not transferable holus bolus to another country. Policies to improve productivity growth in Canada, while informed by the experience of other countries, must be based on the institutional, political and economic realities of this country.

References

Bosworth, Barry and Jack Triplett (2007) "The Early 21st Century U.S. Productivity Expansion is *Still* in Services," *International Productivity Monitor*, Number Fourteen, Spring, pp. 3-19.

Card, David and Richard B. Freeman (2002) "What Have Two Decades of British Economic Reform Delivered in Terms of Productivity Growth?" *International Productivity Monitor*, Number Five, Fall, pp. 41-52.

Cassidy, Mark (2004) "Productivity in Ireland: Trends and Issues," *Central Bank and Financial Services Authority of Ireland Quarterly Bulletin*, Spring, pp.83-106.

Coulombe, Serge, J.F. Tremblay, and S. Marchand (2004) "Literacy Scores, Human Capital, and Growth Across Fourteen OECD Countries," Cat. 89-552-MIE, no. 11, Statistics Canada.

Daveri, Francesco, and Olmo Silva (2004) "Not Only Nokia: What Finland Tells Us About the New Economy," *Economic Policy*, Issue 38, April, pp. 117-163.

Fortin, Pierre (2001) "The Irish Economic Boom: What Can We Learn?" *International Productivity Monitor*, Number Three, Fall, pp. 19-31.

Fortin, Pierre (2005) "From Productivity to Well-being: Keep the Focus on Basic Skills," *International Productivity Monitor*, Number 11, Fall, pp. 3-6.

Gans, Joshua and Scott Stern (2003) "Assessing Australia's Innovative Capacity in the 21st Century," Research Institute of Australia.

Gordon, R. J. (2000) "Does the 'New Economy' Measure Up to the Great Inventions of the Past?" *Journal of Economic Perspectives*, vol. 14, no. 4, Fall, pp. 49-74.

Jackson, Andrew (2005) "Productivity and Building Human Capital for the 'Bottom Third,'" *International Productivity Monitor*, Number 11, Fall, pp. 7-13.

Jorgenson, D. W. and K. J. Stiroh (2002) "Raising the Speed Limit: U.S. Economic Growth in the Information Age," *Brookings Papers on Economic Activity*, No. 1, pp. 125-211.

Lane, Philip (2004) "Discussion on Daveri, Francesco, and Olmo Silva," *Economic Policy*, Issue 38, April, pp. 154-157.

Maliranta, Mika (2001) “Productivity Growth and Micro-Level Restructuring,” ETLA Discussion Paper No. 757, April.

McKinsey Global Institute (1995a) *Sweden’s Economic Performance* (Washington, D.C.: McKinsey & Company).

McKinsey Global Institute (2005b) *Australia’s Economic Performance* (Washington, D.C.: McKinsey & Company).

OECD (2003) *The Sources of Economic Growth*, Paris.

OECD (2004a) “Policy Brief: Economic Survey of Finland,” *OECD Observer*, October.

OECD (2004b) *Understanding Economic Growth*, Paris.

OECD (2004c) *OECD Economic Survey-Sweden*, March.

Oliner, S. and D. Sichel (2000) “The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?” *Journal of Economic Perspectives*, vol. 14, no. 4, Fall, pp. 3-22.

Oliner, S. and D. Sichel (2002) “Information Technology and Productivity: Where Are We Now and Where Are We Going?” *Federal Reserve Bank of Atlanta Economic Review*, vol. 87, no. 3, Third Quarter, pp. 15-44.

Parham, Dean (2002) “Productivity and Policy Reform in Australia,” *International Productivity Monitor*, Number Five, Fall, pp. 53-63.

Parham, Dean, (2004). “Sources of Australia’s Productivity Revival,” *Economic Record*, Vol. 80, No. 249, June, pp. 239-257.

Rao, Someshwar and Jianmin Tang (2001) “The Contribution of ICT to Productivity Growth in Canada and the United States in the 1990s,” *International Productivity Monitor*, Fall, pp. 3-18.

Rao, Someshwar, Jianmin Tang and Weimin Wang (2004) “Measuring the Canada-U.S. Productivity Gap: Industry Dimensions,” *International Productivity Monitor*, Number Nine, Fall, pp. 3-14.

Rao, Someshwar, Andrew Sharpe, and Jeremy Smith (2005) “An Analysis of the Labour Productivity Slowdown in Canada since 2000,” *International Productivity Monitor*, Number Ten, Spring, pp. 3-23.

Sharpe, Andrew (2005) “What Explains the Canada-US ICT Investment Gap?” *International Productivity Monitor*, Number 11, Fall, pp. 21-38.

Sharpe, Andrew (2006) “Lessons for Canada from International Productivity Experience,” CSLS Research Report 2006-02, October.

Stiroh, K. J. (2001) “Is IT Driving the U.S. Productivity Revival?” *International Productivity Monitor* Number Two, Spring, pp. 31-36.

Telecommunications Policy Review Panel (2006) *Final Report*, March (Ottawa: Public Works and Government Services Canada).

Veugelers, R. (2005) “Assessing Innovation Capacity: Fitting Strategy, Indicators and Policy to the Right Framework,” paper prepared for the conference Advancing Knowledge and the Knowledge Economy, National Academies, Washington, 10-11 January.

Appendix Table 1
Output per Hour Levels and Growth Rates in OECD Countries, 1950-2006

	(United States= 100)					(compound average annual growth rates)				
	1950	**1973**	**1995**	**2000**	**2006**	**1950-1973**	**1973-1995**	**1995-2000**	**2000-2006**	**1973-2006**
Australia	73.4	75.3	82.1	82.2	78.2	2.68	1.62	2.31	1.49	1.70
Austria	30.0	62.9	89.2	92.4	89.1	5.91	2.83	3.01	1.71	2.66
Belgium	49.1	79.7	105.2	102.6	95.7	4.75	2.50	1.77	1.16	2.15
Canada	81.0	88.5	85.5	83.2	78.1	2.96	1.06	1.71	1.28	1.20
Denmark	56.5	74.6	97.3	91.8	85.9	3.81	2.44	1.11	1.20	2.01
Finland	33.9	54.5	80.0	81.8	81.7	4.71	2.99	2.75	2.31	2.83
France	42.1	73.9	104.9	104.1	100.1	5.11	2.84	2.13	1.65	2.52
All Germany			88.2	87.0	82.5			2.01	1.42	
West Germany	36.7	75.4	108.3			5.83	2.90			
Ireland	29.0	44.3	79.8	96.7	98.1	4.47	3.96	6.27	2.59	4.06
Italy	42.9	75.9	99.4	93.2	81.2	5.14	2.47	0.97	0.00	1.79
Japan	18.3	51.3	74.0	71.9	71.7	7.27	2.92	1.69	2.28	2.62
Luxembourg	66.7	84.7	106.6	107.2	102.4	3.63	2.28	2.40	1.55	2.17
Netherlands	56.8	84.6	98.9	96.4	91.1	4.36	1.94	1.75	1.38	1.81
New Zealand*	92.0	67.6	64.5	61.8	56.3	1.20	1.01	1.40	0.75	1.02
Norway	51.2	73.8	114.0	114.2	111.1	4.21	3.24	2.31	1.86	2.85
Portugal	18.1	43.3	51.5	54.4	48.3	6.53	2.02	3.39	0.33	1.92
South Korea**	17.8	17.0	38.4	41.2	44.6	2.36	5.03	3.71	3.69	4.59
Spain	21.2	44.5	80.1	71.1	60.7	5.92	3.96	-0.12	-0.33	2.54
Sweden	57.4	80.6	84.5	85.3	86.4	4.09	1.44	2.46	2.56	1.80
Switzerland	73.1	88.7	84.0	81.0	76.9	3.43	0.97	1.55	1.44	1.14
United Kingdom	61.9	66.0	86.6	86.4	84.4	2.85	2.48	2.22	1.94	2.34
United States	100.0	100.0	100.0	100.0	100.0	2.57	1.22	2.28	2.33	1.58
Unweighted Average***	48.1	67.0	86.5	85.0	81.2	4.26	2.46	2.23	1.57	2.25

Source: Groningen Growth and Development Centre and the Conference Board, Total Economy Database, February 2007, http://www.ggdc.net.

* Data for New Zealand are available for 1956 onwards only. The relative level shown for 1950 is actually for 1959, the first year for which data are available for both New Zealand and the United States. The growth rate shown for the 1950-1973 period is actually for 1956-1973.

** Data for South Korea are available for 1963 onwards only. The relative level shown for 1950 is actually for 1963, the first year for which data are available for both South Korea and the United States. The growth rate shown for the 1950-1973 period is actually for 1963-1973.

*** The average excludes the United States for relative levels by includes the United States for growth rates. For 1950 and 1973 and the 1950-1973 and 1973-1995 periods, West Germany is included and All Germany is not included. Fo 1995, 2000 and 2006 and the 1995-2000, 2000-2006 and 1973-2006 periods, All Germany is included and West Germany is not included.

India: Asia's Next Productivity Success Story

Joydeep Mukherji[1]
Standard and Poor's

Abstract

India has created the basic rules of modern economic and political life. While the country's institutional framework needs strengthening, it will allow India to prosper without drastic changes. Gradual economic reform has transformed India, putting it on a much faster growth path. Economic growth in the next ten years may not equal China's current double-digit growth rate, but India is nevertheless very likely to become one of the fastest growing economies in the world, growing at a pace similar to that of Malaysia, Thailand, Taiwan and Korea during their period of sustained rapid economic growth. The recent acceleration in real GDP growth reflects both faster input growth as well as rising total factor productivity. However, India has weaker social pillars to support economic growth than other East Asian countries had at the time of their miracle growth years, mainly due to its poor education system. Failure to address shortcomings in education, along with inadequate physical infrastructure, and large fiscal deficits, would constrain India from reaching even faster growth.

This article reviews recent trends in Indian output and total factor productivity growth, looking at productivity data at the aggregate level and in various sectors of the economy. The article first highlights the importance of a rising savings rate and greater use of capital inputs for growth in recent years. It then examines the factors likely to drive future output and productivity growth. The third section looks at obstacles to faster growth, focusing on shortcomings that have contributed to a relatively small industrial sector in India, compared with other Asian countries. The article concludes that India's emerging policy framework appears to be favorable for both higher factor accumulation and total factor productivity growth in coming years, thanks to economic reform that has generated better incentives for investment and growth.

Recent Trends in the Indian Economy

Output and GDP per capita growth

India is a poor country that is rapidly becoming wealthier. Based on purchasing power parity exchange rates, India's per capita income was only US $3,120 in 2004, ranking it 144th in the global income scale. However, the Indian economy has enjoyed rising growth in recent decades, with real GDP growth climbing from an average of nearly 6 per cent per year during

1 The author is a sovereign credit analyst for Standard & Poor's in New York. This article reflects his personal views and not necessarily those of his employer. Email: joydeep_mukherji@standardandpoors.com.

the 1990s to nearly 7 per cent in 2000-2006 (Table 1). In 2003-2006, it averaged 8.3 per cent per year.

The growth numbers become more vivid if expressed in a different way. From the early 1950s to the early 1980s, India grew at an average annual rate of 3.5 per cent or 1.2 per cent on a per capita basis (Chart 1). At that pace, per capita income doubles only every 57 years. Per capita income has been rising 6.6 per cent annually in the last three years, resulting in a doubling in just less than 11 years. Rising income has helped cut poverty significantly, from 36 per cent in 1993-94 to the current rate of around 20 per cent.[2]

Is India destined to be Asia's next economic miracle? Increasingly, the answer appears to be "Yes". India may not grow as fast as China, which has grown at an average annual rate of 9.5 per cent over the last 20 years. However, India is very likely to remain one of the fastest growing economies in the world in the coming decade, growing at a pace similar to that experienced by Malaysia, Thailand, Taiwan and Korea during their period of sustained high economic growth (Table 1).[3]

India's GDP growth rate has trended upwards in recent years and growth has become less volatile. The coefficient of variation for annual GDP growth fell to 0.3 in 1991-2005, from 0.4 in 1981-90 and 1.0 in 1951-80 (Purfield and Schiff, 2006:Chapter 10). The service sector has led GDP growth, contributing to more than half the total growth in the economy since the 1990s and helping to lessen the country's economic dependence on the monsoon.

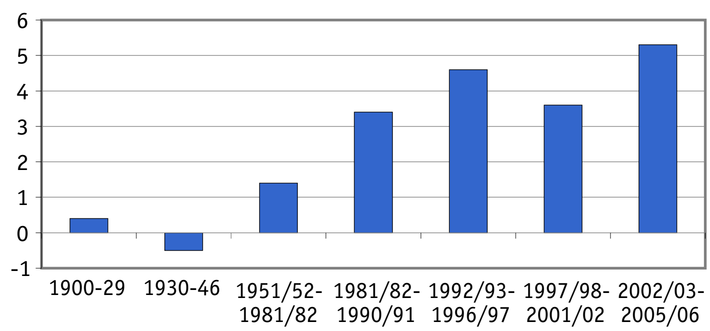
Table 1
Real GDP Growth in Asian Countries During Peak Growth Periods
(average annual per cent change)

India (1990-2000)	5.7
India (2000-2006)	6.9
China (1994-2004)*	9.7-10.4
Hong Kong (1960-1995)	7.7
Korea (1960-1995)	8.1
Singapore (1960-1995)	8.4
Taiwan (1960-1995)	8.6
Thailand (1960-1995)	7.5
Malaysia (1960-1995)	6.9
Japan (1950-1980)	8.0

* The range reflects incomplete national income data in China following a statistical revision done in early 2006.

Source: Anderson (2005) using data from CEIC and the World Bank.

Chart 1
Per Capita GDP Growth in India
(per cent)



Source: Acharya *et al.* (2006).

Growth in India has been driven by the domestic economy, in contrast with the export-led growth that has characterized many East Asian countries. India typically runs a trade deficit and receives foreign direct investment (FDI)

2 The official poverty rate fell to 22 per cent of the population in 2004-05 according to the government of India's National Sample Survey Organization. Indian growth and other data are typically reported by the government using the fiscal year ending on March 31st.

3 The acceleration in Indian growth is consistent with data from the Groningen Growth and Development Centre (http://www.ggdc.net/index-dseries.html#top). Such data show that GDP per person employed (using 1990 dollars adjusted for purchasing power parity) increased only 32 per cent cumulatively during 1980-90 but rose 49 per cent during 1990-2000. The increase for 2000-2006 was 36 per cent, indicating that the total figure for the period 2000-2010 is most likely to exceed that of the previous decade.

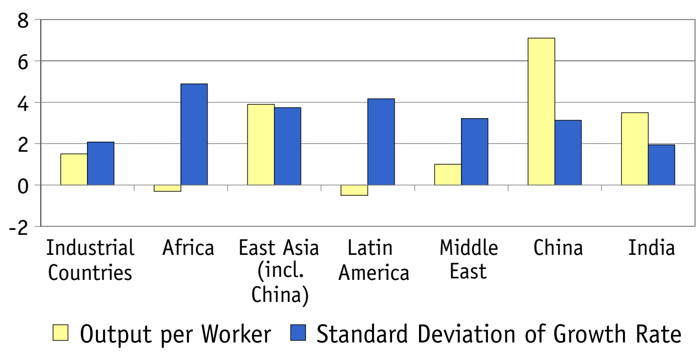
Table 2
Contribution of Total Factor Productivity to Labour Productivity Growth in East Asia

	Average Annual Per Cent Change in Output Per Worker	Contribution of Physical Capital (per cent)*	Contribution of Total Factor Productivity (per cent)*
India (1993-04)	4.6	39	50
China (1993-04)	8.5	49	47
East Asia (excl. China)			
1960-80	4.0	55	30
1980-93	4.6	57	30
1993-03	2.5	72	12

* The rest of the contribution to output per worker growth comes from inputs of land and education, which are not shown.

Source: Table 1, Bosworth and Collins (2006).

Chart 2
Growth in Output per Worker, 1980-2000
(average annual per cent change)



Source: Bosworth and Collins (2003).

of less than 2 per cent of GDP, compared with around 4 per cent of GDP in China and similar levels in Southeast Asia. FDI accounts for around 5 per cent of total investment in India, and is not as strongly connected to exports as in many Asian countries (such as China, where foreign ventures directly and indirectly account for over half of all exports).

Nevertheless, India enjoys a comfortable external position, thanks to FDI and other capital inflows that more than fund its current account deficit. As a result, India's growing foreign exchange reserves now exceed the public sector's external debt. That, in combination with a floating exchange rate that can adjust to external shocks, insulates India from the type of external risk common in many developing countries.

Productivity

The data problems and measurement issues that arise in measuring productivity in industrialized countries are even more daunting in India, due to shortcomings in the statistical system. For example, reliable economy-wide jobs data are available only every five years.[4] With that caveat, this section reviews India's key productivity numbers.

The data indicate that the acceleration in economic growth appears to be coming increasingly from increases in total factor productivity (TFP) rather than greater inputs. A steady increase in TFP appears to be largely driving growth in output per worker. In fact, according to a global survey of productivity trends, TFP accounted for the bulk of the increase in output per worker in India during 1980-2000, higher than in all other regions of the world except China, which had a similar trend (Bosworth, Collins, and Virmani, 2006). Table 2 indicates that improving TFP accounts for a larger share of the increase in output per worker in India in recent years

4 Bosworth, Collins and Virmani (2006) base their productivity estimates on employment data from comprehensive national surveys available every five years, due to the shortcomings of India's annual employment survey data. Indian GDP estimates include both the formal and informal (or "unorganized") sectors of the economy. The estimate of GDP in India's large "unorganized" sector comes from using the labour input method, combined with measures of value added per worker based on enterprise surveys. The labour input data for the unorganized sector (which has the bulk of the workforce) come from surveys conducted every five years. Estimates of value added between the survey years are based on interpolation and estimates after the survey year are based on extrapolation of labour inputs using growth rates between the two most recent benchmark years. The authors state (page 11) that "(t)he problems with annual output estimates in non-benchmark years suggest that debates over the precise timing of changes in India's rate of GDP growth around episodes of economic reform should not be taken seriously."

than it did in East Asian countries during their years of rapid GDP growth.

From a comparative perspective, India has enjoyed better growth in output per worker than many parts of the world in recent decades. Chart 2 indicates that India did much better than Latin America and Africa during 1980-2000 and only slightly worse than East Asia. However, output per worker grew twice as fast in China than in India during that period.

TFP growth appears to have accelerated steadily since the 1980s, according to a study by S. Sivasubramanian (2000). That study also found that TFP accounted for a rising share of output growth in the 1990s (almost 40 per cent) compared with earlier decades.

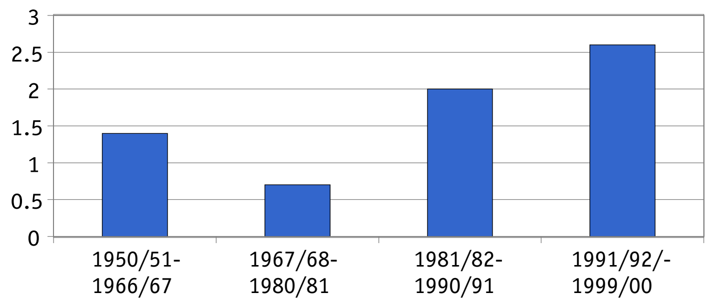
A more recent paper by Barry Bosworth, Susan Collins, and Arvind Virmani (2006) confirms this trend. They find that output per worker grew only 1.3 per cent annually during 1960-1980, when GDP growth was also at a low 3.4 per cent. TFP growth was barely above zero, according to their calculations, indicating that growth in output was almost entirely driven by growth in inputs. In contrast, growth in output per worker nearly tripled to 3.8 per cent during 1980-2004, while TFP increased ten-fold to 2 per cent. A recent IMF paper also finds that TFP started increasing around 1980, rising steadily for the next twenty years (Rodrik and Subramanian, 2004).

The acceleration of economic growth in the 1980s was likely due to a mild dosage of industrial deregulation. However, the spurt in GDP growth proved to be unsustainable as it depended too much on growing government indebtedness.[5] India did not undertake deeper reforms until the early 1990s following a balance of payments crisis that nearly resulted in a sovereign default. The data show that output per worker rose dramatically in the 1990s, along with TFP.

Chart 3

Total Factor Productivity Growth in India

(average annual per cent change)

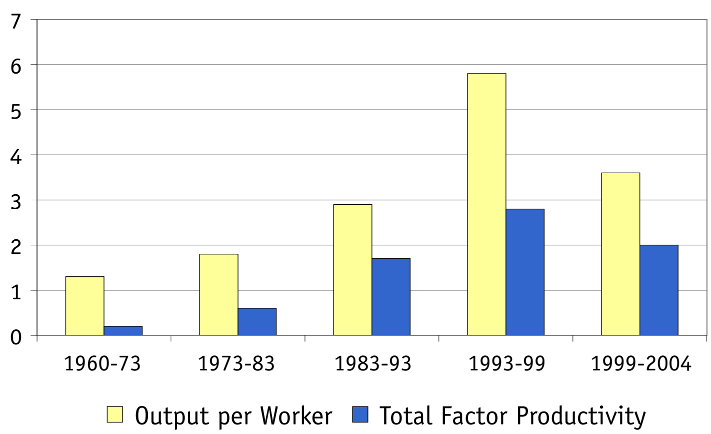


Source: Sivasubramanian (2000).

Chart 4

Labour and Total Factor Productivity Growth in India

(average annual per cent change)



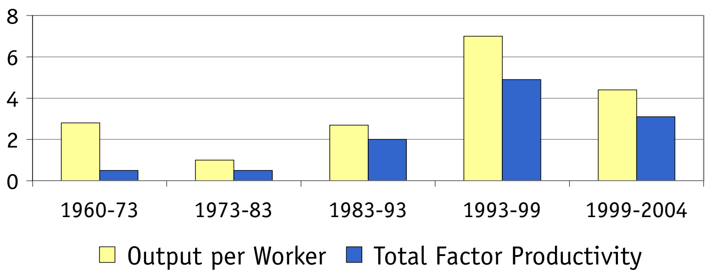
Source: Bosworth, Collins and Virmani (2006).

Bosworth, Collins, and Virmani base their calculations on time periods that coincide with the availability of more comprehensive survey data. Their figures indicate that the growth in output per worker in the economy as a whole averaged 5.8 per cent during 1993-99, compared with 2.9 per cent during the previous ten years (Chart 4). More than half the growth in output per worker during 1983-99 was due to the contribution of

5 For a lively debate on the question of whether Indian GDP growth started to accelerate in the 1980s, before structural reforms began, or in the 1990s, after the government liberalized, see Rodrik and Subramanian (2004) and a rejoinder by T.N. Srinivasan (2004).

Chart 5
Labour and Total Factor Productivity Growth in the Services Sector in India

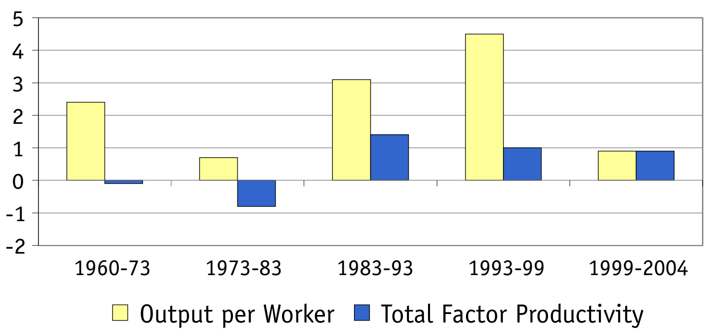
(average annual per cent change)



Source: Bosworth, Collins, and Virmani (2006).

Chart 6
Labour and Total Factor Productivity Growth in Industry in India

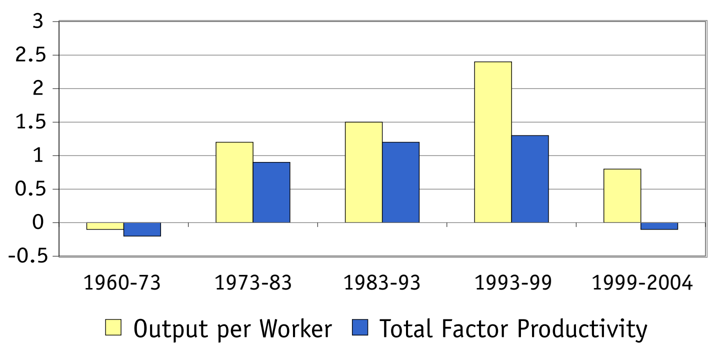
(average annual per cent change)



Source: Bosworth, Collins, and Virmani (2006).

Chart 7
Labour and Total Factor Productivity Growth in Agriculture in India

(average annual per cent change)



Source: Bosworth, Collins, and Virmani (2006).

TFP. In contrast, TFP is estimated to have accounted for only 15 per cent of the growth in output per worker in India during 1960-1973, rising to 33 per cent during 1973-83.

The sharpest improvement was in the services sector, where output per worker grew an astonishing 7 per cent per year in 1993-99, compared with only 2.7 per cent in the previous decade (Chart 5). Much of the growth in the services sector came from the booming information technology and related sectors, such as call offices and back office work, which together employ about 1.6 million people and account for about 3 per cent of GDP (Crisil Research, 2007). However, other service industries, such as insurance, banking, and telecommunications, have also grown rapidly in recent years based on new technology and greater competition.

The industrial sector (which includes manufacturing, mining, electricity and utilities) showed a more modest rise in output per worker, going to 4.5 per cent from 3.1 per cent (Chart 6). Agriculture was the lagging sector, with output per worker rising only 2.4 per cent during 1993-99, compared to 1.5 per cent in the previous decade (Chart 7).[6]

The productivity figures for 1999-2004 are affected by a severe drought that reduced growth in the fiscal year 2003-04 (ending in March 2004), which had an impact on industrial production as well as agriculture. GDP growth accelerated sharply afterwards, averaging over 8 per cent annually. Hence, it is likely that the productivity trend numbers post-2004 are much higher than the levels shown for 1999-2004 in Chart 4.

The recent acceleration in economic growth is also based on greater use of capital, as India's domestic savings and investment rates have increased in recent years. Governments at all levels have reduced their fiscal deficit, thereby

6 Some analysts have questioned the substantial rise in labour productivity and in TFP in the service sector since the early 1990s. It is possible that output in the service sector has been overstated. See Bosworth, Collins and Virmani (2006:21).

boosting the level of public sector savings. Economic reform has also raised the profitability of private investment, leading to a rise in corporate sector savings.

India's domestic savings rate averaged 24 per cent of GDP during the decade of the 1990s (Table 3), before rising to 32 per cent in 2005-06. The increase reflects an impressive turnaround in public sector savings (which rose a net 3.5 per cent of GDP over the period). The numbers indicate that savings and investment in India are largely driven by the private sector, much more than in many developing countries (especially in East Asia). Moreover, the bulk of private savings come from the household sector (and not the corporate sector), in contrast with countries in Southeast and East Asia.[7]

The investment rate has also been rising, reaching 33.8 per cent of GDP in 2005-06 after averaging 24.4 per cent in 1999-2002. Rising GDP growth has led to high capacity utilization rates in industry, which have been hovering over 90 per cent since 2005, spurring firms to invest to increase capacity. FDI inflows may exceed US $10 billion in 2006-07, giving a further boost to investment levels. The gap between the investment rate and domestic savings rate, the "current account" deficit, has been modest in India. The current account was in surplus from 2001 until 2003, before moving into a deficit of around 1 per cent of GDP.

Until the very recent increase in investment levels, GDP growth in India had been less dependent on capital accumulation than that in other fast-growing Asian countries. Growth had been led by the service sector, which relied heavily on labour inputs and is less capital intensive than industry. A World Bank study indicates that the fastest growing sub-sectors of the Indian economy have had lower capital intensities (Mishra, 2004). However, industrial growth has accelerated to above 9.5 per cent since 2004-05, compared with around 7 percent or less in earlier years. Spending on capital-intensive projects, ranging from steel plants to highways, has also picked up, indicating that capital accumulation will likely play a greater role in contributing to future output growth.

Table 3
India's Gross Domestic Savings and Investment
(as per cent of GDP)

	Average 1999-00 to 2001-02	2002-03	2003-04	2005-06*
Household Saving	21.5	22.7	23.8	22.3
Private Corporate Sector	4.1	4.2	4.7	8.1
Public Sector	-1.5	-0.6	1.2	2
of which Government Administration	-5.5	-5.2	-3.7	-
of which Enterprises	4	4.6	4.9	-
Total Savings	24	26.4	29.7	32.4
Gross Domestic Investment	24.4	25.2	28	33.8

* The 2005-06 data are preliminary from the Ministry of Finance.

Source. RBI Annual Report 2005-06. Government of India's Economic Survey 2006-07.

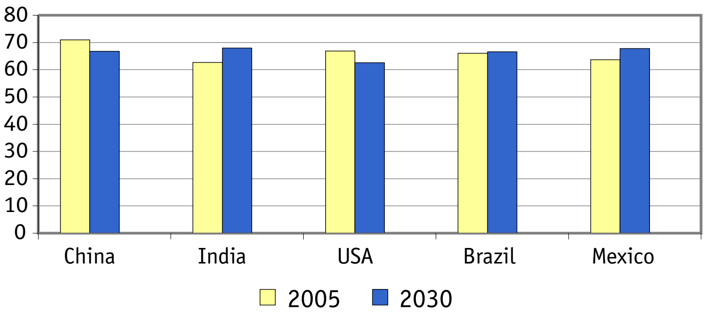
Factors Driving the Economy

Since the early 1990s, the government has enlarged the role of market forces, given more freedom to the private sector, and cut barriers to domestic and foreign competition.

Industrial deregulation, a more flexible exchange rate, stronger debt and equity markets, and lower trade barriers have injected resilience into the economy, dramatically strengthening its external position. The "current account" of India's balance of payments is open and convert-

7 See Mishra (2004) for a discussion on the composition of India's domestic savings. Savings by the "corporate sector" within the private sector typically far exceed "household sector" savings in Korea, Japan, Thailand, Philippines, as well as the United States. The "household sector" in India includes unincorporated businesses, which may distort the comparison with other countries due to differing data definitions. Nevertheless, the level of household sector savings is likely to be quite high even if adjusted for the savings of businesses that are not formally incorporated.

Chart 8
Per cent of Population 15-64 Years



Source: UNDP (2004).

ible and the "capital account" is increasingly open, especially for FDI and foreign portfolio investment. The government has also been loosening controls for Indian corporations to move capital in and out of the country, but maintains restrictions on banks and individuals.

The recent spurt in GDP growth above 8 per cent has generated much debate about its causes, and whether it represents a long-term trend. Most analysts agree that the pace of structural reform (such as privatization, financial sector liberalization, labour law changes) has decelerated since the election in May 2004 of a coalition government led by the Congress Party and supported by Leftist political parties strongly opposed to further liberalization.

The current growth rate likely reflects the lagged impact of earlier reforms that forced many firms to make painful adjustments and become more competitive. It also reflects certain micro-economic reforms started by the previous government (such as tax reform) that have been extended by the current government. Moreover, the impulse for reform has shifted to India's state governments, which are increasingly competing with each other for investment. Some states have become more aggressive than the national government in pursuing pro-growth policies and promoting private investment. Such trends, along with the modest reform initiatives that the current government is able to advance (such as loosening restrictions on FDI and channeling private investment into airports) despite opposition from its coalition supporters, have strengthened private sector confidence about the durability of pro-growth economic policies.

India appears poised for continued strong economic growth thanks to both faster growth in inputs of capital and labour, as well as TFP. Government policy is likely to create better incentives and remove obstacles for investment, as well as raise the level of competition in different markets. Demographic trends should contribute to growth. Over half of India's population is less than 25 years of age, heralding a falling dependency ratio as the labour force grows in coming years. The resulting higher share of the population of working age could boost the country's savings rate (the so-called "demographic dividend"). Chart 8 indicates that India is projected to have a higher share of its population in the prime working age bracket (15-64) than a number of other major countries.

Economic liberalization

The government is likely to continue reducing its direct role in the economy, through gradual privatization and deregulation. Although the central government has largely abandoned the privatization program started by its predecessor, privatization continues at the state level (including in states run by the same Leftist parties who oppose it at the national level). Moreover, central government state-owned enterprises (SOEs) are coming under greater competition thanks to economic liberalization, forcing them to improve their operations. Large SOEs such as telecoms, airlines, oil and gas, steel, insurance and even public sector banks have all lost market share in recent years to private competitors, forcing them to modernize their operations, improve technology, and even reduce their bloated workforces (mainly through voluntary retirement packages and attrition).

The government continues to gradually remove restrictions on private sector investment, recently opening the defense sector to private firms. The sensitive coal sector (which is a major employer in the poorer eastern part of India) has also been partially opened to competition from public sector and private sector firms. The government still "reserves" the production of about two hundred consumer products for small-scale industries (which typically lack the scale and the technology to operate efficiently), but is quietly pruning the list of such industries every year.

Infrastructure investment

Growing investment in infrastructure also augurs well for productivity growth. Some infrastructure sectors are being privatized, such as telecoms and some ports and airports (including in Delhi, Mumbai, Bangalore and Hyderabad). An intensely competitive telecom sector has given Indian consumers some of the lowest long-distance calling rates in the world. The number of phone connections is likely to exceed 250 million in 2007, from barely 20 million at the beginning of the current decade. The government-run Indian railways has recently opened container services to the private sector, thereby spurring much-needed investment and modernization. A massive road-building program is boosting connectivity and lowering transaction costs. The creation of modern highways linking major cities and ports has already reduced transportation costs, allowing firms to operate at a larger scale. Such steps should continue to boost productivity over the coming years.

External integration

The beneficial impact of external liberalization is set to grow as trade barriers fall. Prior to the 1990s, India had the highest tariff barriers on imports of any non-communist country and supplemented them with import quotas and other policies that discouraged trade. Since then, most non-tariff barriers have been removed and tariff rates cut dramatically, with peak tariff rates falling to 10 per cent from 155 per cent. As a result, exports and imports of goods and services have reached one-third of GDP, about double their level in 1990. Exports of goods and services have grown about 25 per cent annually since 2000, compared with 6 per cent during 1995-2000.

The composition of Indian exports has become more diverse and increasingly contains goods that account for a growing share of world trade, auguring well for continued export growth. For example, auto parts exports rose to about US $2 billion in 2006, growing around 40 per cent annually. Exports of passenger vehicles reached over 170,000 in 2005 from 46,000 in 2001 and are poised to continue rising (*Economic Times*, 2007). Intra-industry trade, a good measure of insertion into global production chains, rose to 18 per cent of India's total trade in 2001 from 12 per cent in 1992 (Purfield and Schiff, 2006:chapter 3). India's share of global exports of goods is now about 1 per cent, up from 0.6 per cent in the late 1990s.[8]

The services sector accounts for a growing share of world trade. India's share of global service exports reached 1.4 per cent in 2004, up from 0.6 per cent in 1995. Service exports from the information technology and related business processing operations (such as back

8 Intra-industry trade in East Asia rose to 75 per cent of total trade in 1996-2000 from 42.5 per cent in 1986-90, indicating the greater specialization of production within that region. India's share of goods exports was around 2 per cent of world trade in the 1950s before falling to 0.5 per cent in the 1980s as India pursued an inward-looking growth strategy while many other Asian countries focused on trade and export-led growth. It is interesting to speculate how India would look today had it pursued policies since 1950 that kept its share of world trade at 2 per cent.

offices and call centers) have been growing around 35 per cent per year in recent years and are likely to contribute just over 1 percentage point to GDP growth in coming years. India's competitive advantage in the service sector, thanks to an ample supply of English-speaking technically educated people (compared with most developing countries) augurs well for future export growth.

More competitive factor markets

While deregulation of markets for goods and services should sustain growth prospects, India will also benefit from slowly creating competitive markets for land, labour and capital, the basic factors of production. The country has made more progress in creating competitive markets for capital than for land and labour (the latter is discussed in the next section). Market forces largely allocate and price capital, thanks to financial sector deregulation, and the development of a sophisticated stock exchange.

The Indian financial sector has expanded rapidly in recent years, spurred by growing competition and sustained by continued financial stability. Bank lending is approaching 50 per cent of GDP in 2007 from barely 30 per cent in 2000. Government-owned banks account for about 75 per cent of the assets in the Indian banking system. Their operations have improved in recent years due to growing competition from private sector banks and growing commercial pressure from their minority shareholders. The government has gradually reduced its holding in most public sector banks towards 51 per cent, retaining management control but allowing market forces to have a greater influence over management.

Indian firms increasingly benefit from maturing stock markets. India's National Stock Exchange and the Bombay Stock Exchange are ranked third and fifth respectively in the world by the number of transactions. They are increasingly approaching world-class standards thanks to computerization, modernization of the market infrastructure, an improving regulatory and legal infrastructure, and the availability of ample trained personnel. Economies of scale (due to the large number of companies and speculators), plus better infrastructure make it easier for firms, especially mid-size firms by global standards, to gain access to liquid equity markets in India than in most developing countries. For example, many mid-size Indian firms have been able to raise as little as US$15-20 million easily through initial public offerings, an advantage compared with their competitors in many emerging markets.

The development of a market for capital has exceeded the development of a market for land. Poor land records, inflexible zoning laws, and continued government intervention have constrained the development of genuinely competitive markets for land. Ownership of land is unclear or in dispute in much of the country. However, many states have progressed in computerizing land titles, thereby reducing uncertainty and the cost of transactions. Over time, this should facilitate more land sales, as well as encourage the use of land as collateral for loans.

The acquisition of farmland for building industrial zones, and the resulting displacement of farmers, has created immense controversy. Various state governments are now experimenting with different policies for acquiring such land and for compensating the owners. Over time, more states are likely to discard the currently predominant policy of forcing farmers to sell their land directly to the government for re-sale to private developers, an opaque procedure that gives scope to corruption. Several states are now experimenting with flexible zoning and tenancy laws, moving towards a genuine land market with a diminished role for the government as an intermediary.

The positive impact of flexible markets is already apparent in growing investment to connect farmers directly with retail consumers, a development that should sustain productivity and economic growth in coming years. Deregulation, the building of rural roads, and the growth of sophisticated commodity markets is already transforming Indian agriculture. Private firms are increasingly supplying more inputs and buying more output directly from the farmer, cutting out the middleman. Financial institutions are becoming more active in funding agriculture, especially under new arrangements such as contract farming and futures markets that increasingly separate and re-allocate the risks in farm production. The recently started re-organization of farm production with better technology, more specialization, greater quality control, and standardization will facilitate the growth of agro-industry and better supply chains. That, along with deeper spot and futures markets for agricultural commodities, will facilitate the diffusion of technology and boost output and labour productivity on the farm.

A maturing private sector

During the first decade of reform in the 1990s, Indian firms gained experience in improving management practices, acquiring new technologies, re-organizing production processes, and learning to tighten their supply chain. India's earlier investment in the public institutions of a modern economy, including a legal system, property rights, and technical and management education facilitated this quick adaptation. The impressive level of "learning by doing" was accompanied by much "creative destruction", as many old firms declined or went out of business in a more competitive environment, replaced by new firms.

Since 2000, more Indian firms have moved to the global stage, investing or trading abroad. Firms in sectors such as steel, auto parts, pharmaceuticals, machine tools, packaging, information technology, mining, pulp and paper, and oil refining have undertaken massive outbound FDI (including mergers and acquisitions). Overseas bids by Indian firms exceeded US$20 billion in 2006. As a result, a growing segment of India's corporate sector is now fully subject to global competition, trends, and ideas, auguring well for their own productivity growth and its spillover into the rest of the economy.

The growth of more sophisticated Indian firms will create a globally-oriented private sector that can leap ahead of its counterparts in many other Asian countries that are on the whole more prosperous. New entrants to the global economy often create new business models that undermine the competitiveness of older firms, as Japanese car firms did to their American competitors. Indian firms may create their own business models in key sectors, especially in services. For example, new private hospital chains in India are experimenting with combinations of technology, information systems, and corporate organization that could make them more efficient than their counterparts abroad, who are hindered by their legacy. Corporate India will likely have a disproportionately larger international presence for a country of India's low per capita income, thanks in part to its large absolute size and its familiarity with English.

These trends suggest that India's GDP could grow steadily around 7-9 per cent per year in the coming decade. For India to grow at a faster pace, it would have to address the constraints described in the next section.

Factors Constraining the Economy

The recent improvement in the health of India's private sector contrasts with the deep-seated problems of the public sector, which have led to inadequate public investment in infrastructure, education and health care. Moreover, public institutions, including the bureaucracy, have been weakened and politicized in recent decades, limiting their ability to act quickly, impartially and effectively. As a result, India's growth path will continue to differ from that of many East Asian countries (such as China and Korea) where the public sector successfully mobilized vast resources into building infrastructure and was able to provide services such as education and health care to improve the level of human capital.

Fiscal deficits

India's poor fiscal performance constrains its growth prospects. The country's general government deficit (which includes the central and state governments) has averaged 8 per cent of GDP since 1980 (Acharya *et al.*, 2003). The deficit reached a peak of almost 10 per cent of GDP in 2002-03 before declining to around 7 per cent in recent years, thanks to buoyant revenue growth. Computerization, aggressive tax reform to cut rates, widening of the tax base, as well as the introduction of a limited value added tax at the state level, have boosted tax revenues.[9]

The importance of fiscal correction is highlighted by a World Bank study that indicates that an increase in public sector savings by 1 percentage point of GDP results in total savings rising by 0.67 percentage points of GDP (Mishra, 2004). The same study calculates that a one percentage point increase in the share of the working age population in the total population leads to an increase in the savings rate by 0.88 percentage points.

The historically poor fiscal performance has not led to a crisis, but it exacts a toll on the economy. Budget deficits swallow much of the country's financial savings, leaving less money available for the private sector to invest. About 30 per cent of the government's revenues are devoted to paying interest on its debt, and much of the rest to paying salaries for a bloated civil service. As a result, the government has scant resources for providing public services and for investing in infrastructure such as roads and power supply. Moreover, the composition of public spending (i.e. the large share going to salaries and subsidies instead of investment) means that India will continue to have weaker social pillars to support GDP growth than East Asian countries at the time of their miracle growth years.

The key to sustaining recent fiscal progress, and thereby sustaining economic growth, lies in moving to a national goods and services tax, which the government hopes to implement in 2010. The higher tax revenues at both the central and state level from such tax reform could reduce the fiscal deficit and, if combined with restraint on current spending, could allow for more public sector investment. Moreover, the new tax system would boost economic efficiency. The current system of excise taxes, sales taxes and other levies segments India into many state markets. A national level goods and services tax would create a true national market, and boost output and productivity by allowing firms to optimize the location of production, logistics and storage.

Poor infrastructure and business conditions

Poor physical infrastructure also constrains India's growth. According to IMF estimates, Indian firms lose around 9 per cent of the value of their sales due to power shortages, compared with about 2 per cent in China, less than 3 per cent in East Asia on average, and less than 6 per cent in Pakistan (IMF, 2006). The cost of electricity for industrial users is also much higher than average costs in Southeast Asia or Latin America. India's money-losing state electricity boards recover around 70 per cent of the cost of supplying power. Their losses make it difficult to invest in providing reliable power, let alone

9 The consolidated tax revenues of the state and central governments are likely to exceed 17 per cent of GDP in 2006-07 from below 14 per cent in 2001-02.

increase generating capacity to overcome power shortages (the peak shortage in electricity supply is above 12 per cent). As a result, over 60 per cent of Indian manufacturing firms rely on their own generators for power, raising the cost of doing business. Captive power plants account for about 25 per cent of total capacity in India and may account for more in the coming decade.

Economic growth is also constrained by a poor regulatory and bureaucratic climate. For example, World Bank surveys show that the number of days to start a business in India is 89, compared to 41 in China. India ranked 76th in a list of 117 countries in terms of the burden of regulations imposed on the private sector (China ranked better at 30th) (Purfield and Schiff, 2006).

Rigid labour laws

Infrastructure and regulatory shortcomings have combined with rigid labour laws to restrict the growth of new jobs. Rigid labour laws make firms reluctant to hire workers in good times for fear of not being able to shed them in bad times. World Bank indices on the rigidity of hiring, and especially firing, a worker show that Indian firms suffer from more rigidity than firms in China, Russia and Malaysia.

According to IMF calculations, a percentage point increase in output in the "organized sector" of the economy leads to a half percentage point increase in the number of jobs (Purfield and Schiff, 2006:17).[10] Only about 10 per cent of the labour force is in the "organized sector" but it has the best paid and most productive part of the workforce. The low elasticity of job creation with respect to output growth reflects the incentives employers face to substitute machinery and equipment for labour, a perverse outcome in a country with abundant labour. As a result, output per worker may be increasing faster than would be the case if labour markets were more flexible and facilitated the hiring of more unskilled workers in the organized sector.

India's labour laws fall under the jurisdiction of both the central and state governments. The central government is unable to loosen the law due to opposition within the Congress Party and from its Leftist supporters outside the government. In contrast, many state governments have been vocal in demanding more flexible labour laws, but they cannot act alone. However, in practice, many state governments (whose task it is to apply most of these laws) have ceased to be vigilant in enforcing the law, creating some de facto labour flexibility (especially in the states of Andhra Pradesh and Gujarat).

Most companies try to gain flexibility by relying on informal labour in the "un-organized" sector. Many firms overcome legal obstacles by offering voluntary retirement packages to redundant workers and by relying on sub-contractors who enjoy greater flexibility. The current laws impose a cost on many firms, as well as preventing workers in the vast "un-organized" sector from entering the more lucrative and secure "organized" sector of the labour market.

Labour law liberalization would increase both employment and growth by removing an important barrier for the expansion of low-skilled manufacturing. Progress in this regard will be slow in the coming years, but may accelerate if the opposition Bharatiya Janata Party returns to power after the next elections (since they have committed to liberalizing labour laws).

Low level of human capital

The micro-economic rigidities that constrain productivity growth are compounded by India's generally low level of human capital. Only 76 per cent of youth aged 15-24 are literate, based on

10 The "organized" sector in India is defined as firms with 100 employees or more and no electricity or firms with 50 employees or more with electricity.

Table 4
Industry as per cent of GDP

	1980	2004
India	28	27
China	42	46
Thailand	37	44
Malaysia	42	50
Latin America & Caribbean	36	34
East Asia & Pacific	40	45

Source: *World Development Indicators, 2006*.
Note: Industry includes mining, manufacturing, construction, and utilities.

their ability to read and write simple statements (World Bank, 2006). The average number of years of schooling was 4.5 in 2000 in India, lower than China (6.4), Thailand (6.5), Malaysia (6.8), and Indonesia (5.0). In fact, China and Malaysia scored higher in 1980 than India scored in 2000, and Thailand was almost at the same level. Only 14 per cent of Indian workers aged 15-64 had completed secondary education in 2004 and only 6 per cent had a university education (Bosworth, Collins, and Virmani, 2006:Tables 7 and 8). The low figures indicate that India's "demographic dividend" is a two-edged sword. It could create immense problems if India fails to create enough jobs for the growing workforce, and to increase their skills.

Weakness of the industrial sector

The shortcomings discussed above have constrained the growth of Indian industry, which faces handicaps in fully utilizing resources like land and labour in the most efficient manner. The service sector, by comparison, has greater scope to work around these impediments, especially labour laws. Partly as a result, both manufacturing and the wider industrial sector as a whole account for a smaller share of India's GDP and its labour force than in other developing countries. Manufacturing accounts for only 17 per cent of India's GDP, compared with over 30 per cent in China and 25-35 per cent in Southeast and East Asia. The industrial sector as a whole accounts for only 27 per cent of GDP, and services account for 51 per cent, giving India a premature profile of a rich country past its industrializing years (Table 4).

The comparatively slow pace of industrialization in India has a direct impact on poverty by limiting the movement of workers out of low-wage agriculture. The share of the total workforce in agriculture was 71 per cent in 1978 in both China and India. However, it has fallen in recent years to only 47 per cent in China, compared with 57 per cent in India (Bosworth and Collins, 2006:Table 3). Employment growth in the manufacturing sector averaged around 2.5 per cent per year in India in the 1990s, compared with about 4-6.5 per cent in Southeast Asian countries during their years of rapid industrialization (Mohan, 2002).

The shift of labour from agriculture to other sectors (which have higher productivity levels) has likely contributed one percentage point to output per worker growth in India since 1993 (Bosworth, Collins, and Virmani, 2006). India's industrial growth has accelerated to over 9.5 per cent annually since 2004-05, well above the pace of advance in the previous decade. Higher growth has likely accelerated the shift of labour from agriculture to industry, thereby boosting overall productivity in the economy in the last four years.

Historically, India placed comparatively greater investment in higher education than in basic education, compared with most East and Southeast Asian countries. That legacy, plus other policies that hindered labour-intensive manufacturing, have created an unusual pattern of output in comparison with other developing countries. Indian firms now specialize in skill-intensive manufacturing sectors, competing with firms in much richer countries such as Malaysia and Korea.

According to an IMF study, the pattern of output in India's faster growing states is similar to that of much richer industrial countries (Kochhar, Kumar and Rajan, 2006). The share of manufacturing in total output in those states has either been constant or declining, in contrast with the opposite experience of East and Southeast Asian countries at a similar level of income. In some cases, the share of manufacturing in total output in fast-growing Indian states has increased due to the growth of sub-sectors that rely heavily on skills or capital, not on unskilled labor. While gradual liberalization of labour laws may change this pattern of output, the legacy of India's development pattern may lead it to specialize in the manufacture of goods that require more skill, compared with other countries at the same level of wealth.

Conclusion

India has created the basic rules of modern economic and political life. While the country's institutional framework needs strengthening, it will allow India to prosper without drastic changes. Modern economic and political institutions, such as the rule of law, property rights, and political democracy, are largely in place. The institutions, especially the public sector, need improvement but not drastic surgery.

India is unique in being a democracy for sixty years without moving towards free markets until barely fifteen years ago. It is now reaping its earlier investment in political development, as well as its later investment in economic reform that has unleashed the potential that was created, but underutilized in the first four decades after independence. The stock of highly educated people, the legal and regulatory framework, and the familiarity with business processes are all quite advanced for a country at India's current level of per capita income.

Over the next decade, India is likely to grow at a rate approaching that experienced by East Asian countries during their peak growth years, but with some differences. India does not have a political system that can centrally mobilize capital as rapidly and as extensively as those countries. India's looser institutional and political framework may have contributed to lower growth in factor inputs (especially capital) in the past, and hence in GDP growth, compared with East Asia. However, India's emerging policy framework appears to be favorable to both higher factor accumulation and TFP growth in coming years, thanks to reform that has generated better incentives for investment and growth.

India's GDP growth in recent years has depended proportionately more on TFP than on capital accumulation, compared with China and other fast growing countries. This is partly due to India's growth strategy, which is largely based on the market cost of capital (in contrast with subsidized capital in China and many East Asian countries during their years of rapid growth). It is also due to the comparatively weaker development of Indian industry and physical infrastructure, which requires more capital spending. However, recent policy changes have sparked more investment in infrastructure, implying that capital accumulation could play a proportionately larger role in Indian growth in coming years.

On the whole, the Indian economy appears set to meet the challenge of accumulating more capital, provided that the government controls its fiscal deficit (to avoid lowering public sector savings), and continues with the liberalization of more sectors of the economy. The industrial sector is poised to contribute to a larger share of GDP growth in coming years. The distinction between India as the "back office" and China as the "workshop" of the world is disappearing, as Indian industry grows. Growth in agriculture is likely to accelerate moderately in coming years, at least in those parts of the country where the conditions are favorable for agro-industry. Finally, recent political debate in India on problems in health and education could lead to innovative policies that raise the level of human capital.

In contrast with China and East Asia (during their period of rapid growth), India has seen power at the national level rotate across all major and most minor political parties in the last two decades. During the same period, the consensus on pro-investment and pro-growth policies across the political spectrum has only strengthened. Hence, India is less vulnerable to sharp changes in economic policy in coming years, despite the likelihood of rule by shaky coalition governments.

India is a successful case of globalization. The country's basic features are more likely to be strengthened than threatened by more integration with the world economy. Its political system will become more transparent with growing prosperity, a burgeoning middle class, and greater media scrutiny. Its legal system is coming under greater pressure to provide speedier decisions and faces more scrutiny for its integrity. India's regulatory system is catching up with the framework of modern economies, with stronger regulators in the stock market, telecom and insurance sectors and new regulators emerging in other infrastructure sectors (such as airports, oil and gas). Its central bank is becoming a more nimble institution that can better focus on monetary policy and manage a more sophisticated economy.

From an economic perspective, India has been a success but a qualified one. From a broader perspective, India has been a more notable success as a diverse and democratic country with immense poverty that has managed to gradually liberalize and integrate with the global economy while enjoying steady economic growth and rising living standards.

References

Acharya, Shankar, Isher J. Ahluwalia, K.L. Krishna, and Ila Patnaik (2003) "India: Economic Growth, 1950-2000: From Regulations to Reforms: What Factors Can Explain India's Growth Record Since 1950?" Indian Council for Research on International Economic Relations (ICRIER).

Anderson, Jonathan (2005) "How to Think About China (Part 5)," UBS Investment Research, Nov. 15.

Bosworth, Barry and Susan Collins (2003) "The Empirics of Growth: An Update," September, Brookings Institution, Washington, D.C.

Bosworth, Barry and Susan Collins (2006) "Accounting for Growth: Comparing China and India," draft paper, November, Brookings Institution and Georgetown University, Washington, D.C.

Bosworth, Barry, Collins, Susan and Arvind Virmani (2006) "Sources of Growth in the Indian Economy," paper presented to the Indian Policy Forum, New Delhi, July.

Crisil Research (2007) "The Rising Tide - Employment and Output Linkages of IT-ITES," February, Mumbai.

Economic Times (2007) "India zooms past China in car exports," January 8, Mumbai.

IMF (2006) "India: 2005 Article IV Report", Washington, D.C.

Kochhar, Kalpana, Utsav Kumar and Rajan Raghuram (2006) "India's Pattern of Development: What Happened, What Follows," IMF Working Paper No. 06/22, January.

Mishra, Deepak (2004) "Can India Attain East Asian Growth with South Asian Savings Rate?" July, World Bank.

Mohan, Rakesh (2002) "A Decade After 1991: New Challenges facing the Indian Economy," *Reserve Bank of India Bulletin*, November, p.780.

Purfield, Catriona and Jerald Schiff, eds. (2006) *India Goes Global: Its Expanding Role in the World Economy*s (Washington, D.C.: IMF).

Rodrik, Dani and Arvind Subramanian (2004) "From Hindu Growth to Productivity Surge: The Mystery of the Indian Growth Transition," IMF Working Paper No. 04/77, May.

Sivasubramanian, S. (2000) *The National Income of India in the Twentieth Century*, (New Delhi: Oxford University Press).

Srinivasan, T. N. (2004) "Comments on Paper by Dani Rodrik and Arvind Subramanian," http://www.imf.org/external/pubs/ft/staffp/2004/00-00/sriniv.pdf

UNDP (2004) "World Population Prospects," New York.

World Bank (2006) *World Development Indicators*, Washington, D.C.

Can Measurement Error Explain the Weakness of Productivity Growth in the Canadian Construction Industry?

Peter Harrison[1]
Finance Canada

ABSTRACT

According to Statistics Canada productivity estimates, the rate of growth of real output per hour in the construction industry in Canada over the 1981-2006 period was 0.53 per cent per year, one-third of the business sector average. This article examines evidence for and against the hypothesis that measurement error explains this below average productivity performance. The article finds that the use of input cost indexes to adjust nominal output to obtain real output, instead of the more appropriate use of output price indexes, for certain sub-industries of the construction sector represents the most likely source of measurement error. This procedure may result in a downward bias to labour productivity growth in the construction sector of up to 0.44 percentage points per year. It is thus likely that measurement error explains some, but not all, of the gap in labour productivity growth between the construction industry and the business sector.

ACCORDING TO STATISTICS CANADA productivity estimates, the rate of growth of real output per hour in the construction industry in Canada over the 1981-2006 period was 0.53 per cent per year, about one-third of the business sector average of 1.46 per cent. Construction industry practitioners have expressed scepticism over the Statistics Canada figures. Similar concerns about the reliability of official construction productivity estimates have been raised in other OECD countries. A number of studies have found significant productivity gains for many tasks in the construction industry, a result which appears inconsistent with the weak aggregate productivity gains in the industry recorded by Statistics Canada.

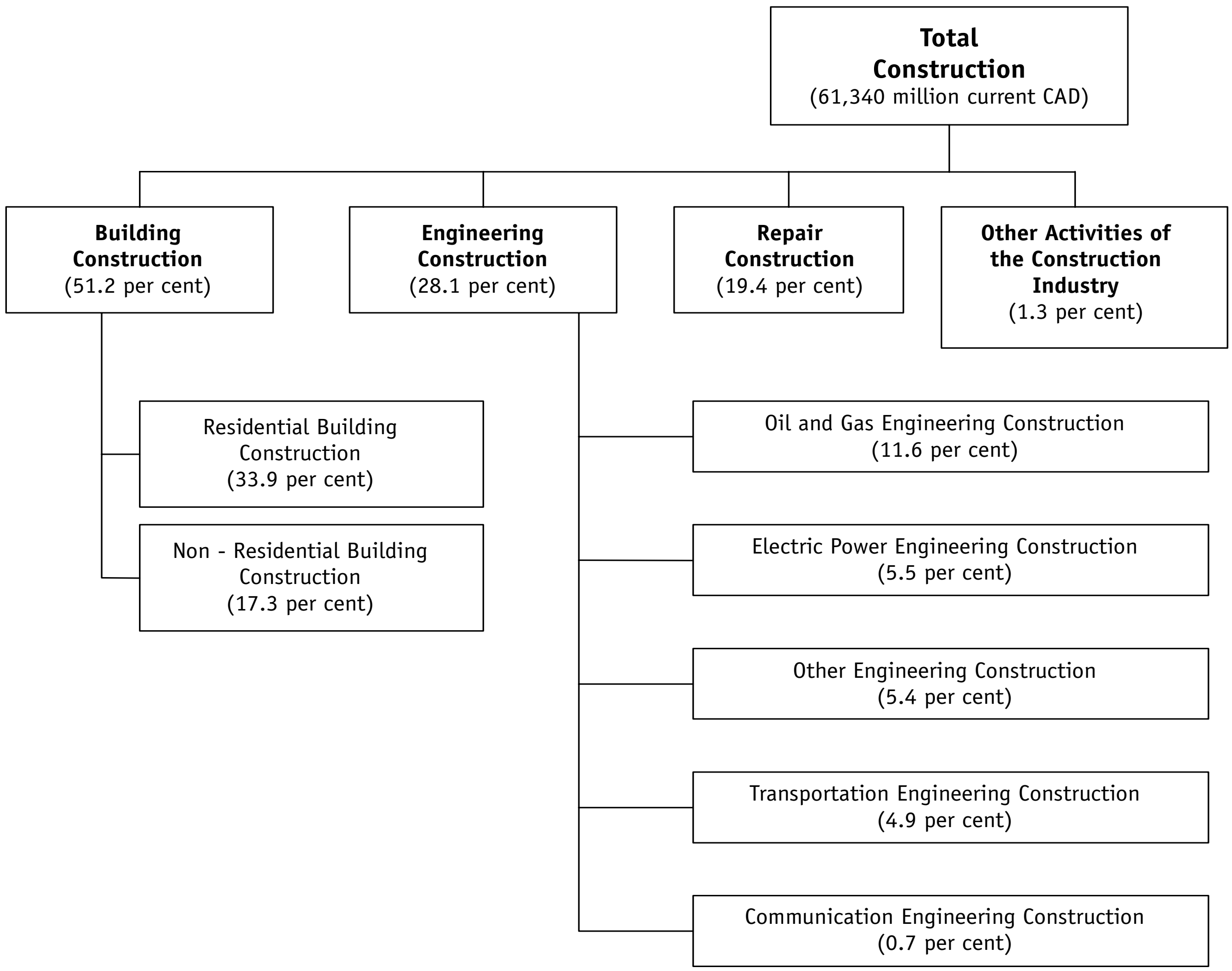
The objective of this article is to assess the reliability of the official Statistics Canada pro-

1 The author is an economist in the Fiscal Policy Division at Finance Canada. This article is an abridged version of a much longer report (Harrison, 2007) prepared for the Construction Sector Council in early 2006 when the author was employed by the Centre for the Study of Living Standards. The view expressed in this article are those of the author and do not necessarily reflect those of Finance Canada. The report was presented at a meeting of the Construction Sector Council in Kelowna, British Columbia in February 2006 and at the annual meeting of the Canadian Economics Association in Montreal in May 2006. The author would like to thank Jean-François Arsenault and Sharon Qiao for assistance in the preparation of the report; Statistics Canada officials who responded to numerous questions on how construction sector productivity estimates are compiled; the members of the Labour Market Information Committee of the Construction Sector Council who were interviewed for the study; Andrew Sharpe and Pierre Fortin for useful comments; and George Gritziotis and Rosemary Sparks from the Construction Sector Council for support of the project. Email: harrison.peter@fin.gc.ca.

Chart 1

The Organization of the Construction Industry

(share of value added in total construction, current dollars, 2003)



Note: 2003 is the most recent year for nominal output in construction.

ductivity estimates for the construction industry in light of the industry perspective that there have been significant labour productivity gains in the industry. Construction practitioners argue that Statistics Canada is failing to capture productivity gains in the construction industry because of measurement issues.

The article is divided into five sections. The first section discusses the organization of the construction sector in Canada. The second section examines labour productivity trends and levels in the construction sector in Canada since 1961. Section three reviews the evidence supporting the mismeasurement hypothesis, particularly the issue of whether input-cost based deflators have an upward bias. Section four examines the evidence that does not support the mismeasurement hypothesis. Section five concludes.

The Organization of the Construction Industry in Canada

From the point of view of those who analyze productivity, construction is divided into three main sub-industries: building construction, engineering construction and repair construction.[2] Building construction is further subdivided into residential and non-residential building construction, often considered separate industries.

The sub-industries within the construction industry are not of equal size in terms of the value added they generate (Appendix Table 1). Based on data from 2003, the latest year for which current dollar output data are available, residential construction was by far the largest sub-industry with 33.9 per cent of total value added. Non-residential building accounted for 17.3 per cent of value added. Together residential and non-residential building construction thus accounted for slightly more than half of total value added in the construction industry (51.2 per cent).

Engineering construction accounted for 28.1 per cent total value added in the construction industry. Within engineering construction, oil and gas engineering construction was the most important component at 11.6 per cent of construction value added. Electric power engineering (5.5 per cent), other engineering (5.4 per cent), transportation engineering (4.9 per cent), and communication construction (0.7 per cent) were the other components.

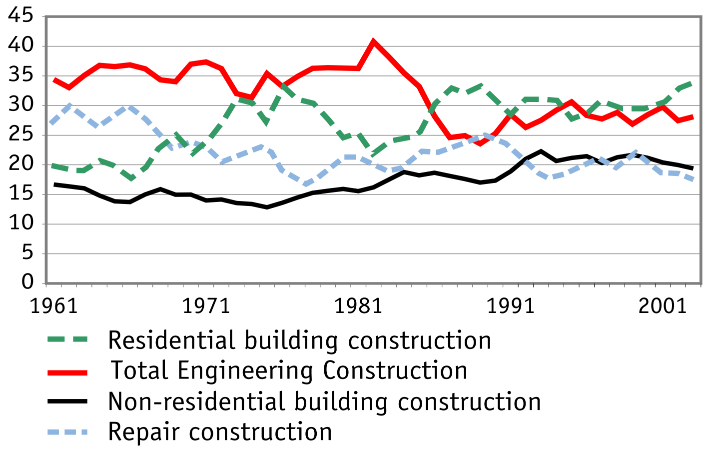
Repair construction constituted 19.4 per cent of construction industry value added. Other activities of the construction industry accounted for only 1.3 per cent of value added in 2003.

While looking at a snapshot of the composition of the construction industry in one year is informative, it does not provide a complete picture, since over time there have been important changes in the relative importance of different sub-industries (Chart 2). Interestingly, the high

Chart 2

Shares of Total Output, Construction Industry, Canada

(current dollars, per cent, 1961-2003)



Source: Statistics Canada: CANSIM Table 379-0023.

relative importance of residential construction is only a recent trend. Between 1961 and 1986 engineering construction was the most important sub-industry.[3] Non-residential building construction has shown a fairly steady downward trend over the entire period. Repair construction has shown a slightly increasing trend.

Productivity Trends in the Construction Sector in Canada

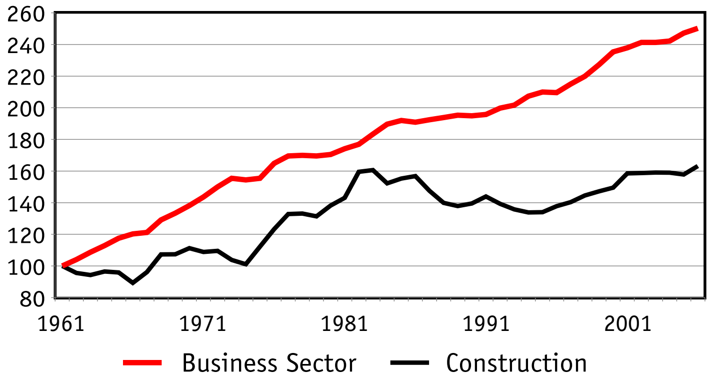
Overall productivity trends

Based on Statistics Canada estimates, the productivity performance of the construction industry in Canada since 1961 has been relatively poor in comparison with that of the business sector as a whole. Output per hour in the construction industry in 2006 was 63 per cent higher than it was in 1961, equivalent to an aver-

2 The fourth sub-industry, "Other Activities of the Construction Industry" is heterogeneous and very small (Chart 1), so it will not be included in this analysis.

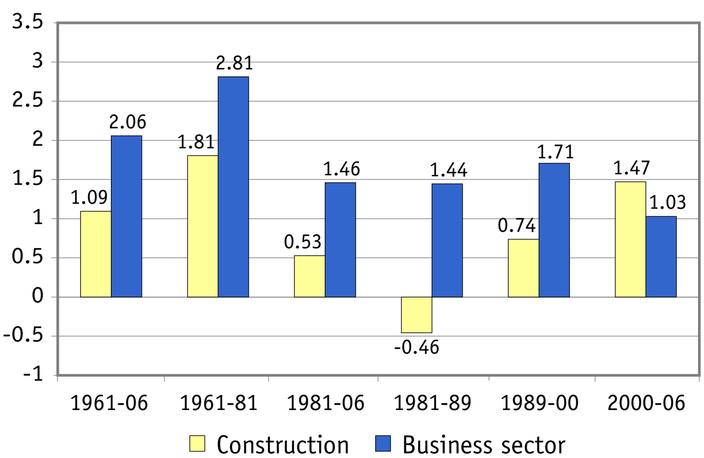
3 Within engineering construction there have been significant shifts in the relative size of the sub-industries. The importance of oil and gas construction has waxed and waned with the state of the wider energy sector, with peaks in 1971, 1982, and a recent increase beginning in the early 1990s. Electric power engineering construction has also changed in importance peaking in the late 1960s, late 1970s, and early 1990s. Transportation engineering construction has gradually declined in relative importance since a peak in the mid-1960s. Both communications engineering and other engineering construction have exhibited long-run downward trends.

Chart 3
Index of Labour Productivity (output per hour), Construction Industry and Business Sector, Canada, 1961-2006



Source: Calculated by CSLS from Statistics Canada Productivity Measures.

Chart 4
Labour Productivity (output per hour) Growth Trends, Construction Industry and Business Sector, Canada, 1961-2006



Source: Calculated by CSLS from Statistics Canada Productivity Measures.

age annual rate of increase of 1.09 per cent (Chart 3 and Chart 4).[4] This was only less than one half the rate of increase of the business sector, which saw productivity advance 150 per cent between 1961 and 2006, or 2.06 per cent per year. Since 1981, output per hour in the construction sector has only advanced at a 0.53 per cent average annual rate, one-third that of the 1.46 per cent rate in the business sector.

The construction industry experienced extremely strong labour productivity performance between 1974 and 1983, with output per hour up 59 per cent. Since then productivity growth in the construction sector has been disappointing, up only 1.7 per cent or 0.1 per cent per year. Indeed, virtually all of the productivity growth in the construction industry in the period from 1961 to 2006 took place during the brief 1974-1983 period. While business sector productivity has grown more or less continuously between 1961 and 2006, the construction sector suffered absolute declines in productivity between 1961 and 1966, 1970 and 1974, and 1983-1994 periods. Productivity growth picked up after 1995, advancing at a robust pace to 3 per cent per year until 2001. It then stagnated over the 2001-2005 period, before picking up in 2006, when, according to preliminary estimates, it rose a robust 3.5 per cent.

Productivity trends by construction sub-industry

The productivity growth of the non-residential construction greatly outperformed that of the other sub-industries over the 1961-2001 period[5] (Chart 5), advancing at a 2 per cent compound annual rate. Productivity in residential construction and repair construction grew at less than half that rate (0.54 and 0.52 per cent per year respectively). Productivity growth in engineering construction advanced an even weaker 0.4 per cent for the 1961-1997 period.[6]

4 There are currently no official Statistics Canada pre-1997 estimates of labour productivity for the construction sector based on the North American Industry Classification System (NAICS). These estimates will be released later in 2007. This article uses estimates for the 1961-1997 period based on the Standard Industrial Classification (SIC) (and NAICS–based estimates for the 1997-2006 period). Construction productivity growth rates for the pre-1997 period may change significantly with the release of NAICS-based estimates.

5 Unfortunately, data at the sub-industry level are not available after 2001, and in the case of engineering construction excluding repairs, after 1997.

There was considerable variation in the productivity growth of the construction sub-industries within the 1961-2001 period, as can be seen in Chart 6.

Productivity levels by industry

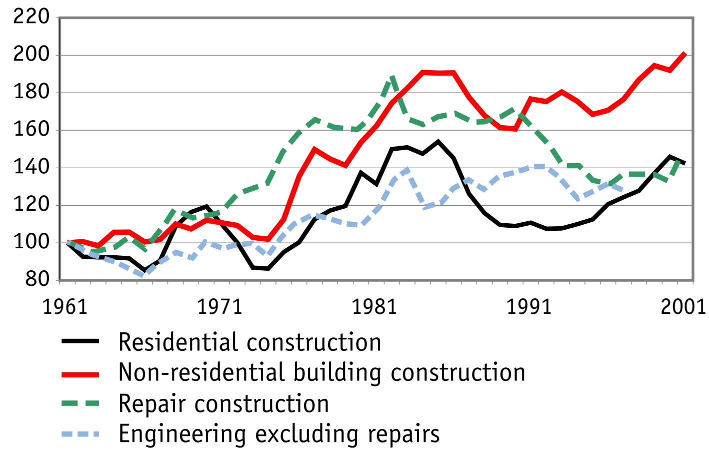
Labour productivity levels can be calculated using estimates of hours worked from the Statistics Canada productivity program and gross domestic product at basic prices estimates. Because we are doing cross-industry analysis, we use current dollars data to avoid the distortion due to relative price changes embedded in constant dollars estimates. The comparison focuses on 2003, the most recent year for which current dollar estimates are available.

Based on 2003 estimates, labour productivity in Canada averaged $43.97 per hour. The construction industry at $33.03 per hour, or 75 per cent of the all industries level, ranked eleventh among the 18 NAICS industries. It ranked fourth among the goods-producing industries, ahead of agriculture (60 per cent) but lagging manufacturing (106 per cent). Because of high levels of capital intensity, the mining, oil and gas sector (443 per cent) and the utilities industry (328 per cent), both have very high levels of labour productivity compared to the industrial average.

Evidence Supporting the Mismeasurement Hypothesis

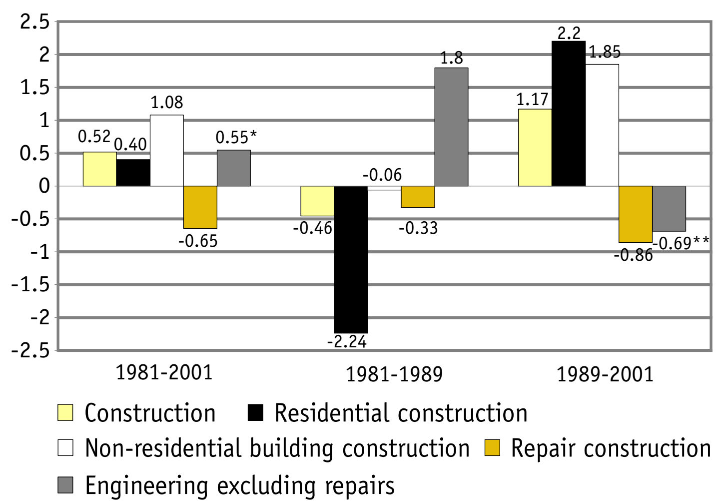
At least five pieces of evidence suggest that official estimates of productivity growth may underestimate true labour productivity growth in the construction industry in Canada. These are the use of input cost indexes to deflate nominal output, strong construction productivity gains in other countries, significant task-based

Chart 5
Indexes of Labour Productivity, Construction Sub-industries, 1961-2001
(1961 = 100)



Source: Harrison (2007:Appendix Table 8).

Chart 6
Output per hour Trends, Construction Industry and Component Sub-industries, Canada, 1981-2001



Source: Harrison (2007:Appendix Table 8).

Note: There are four components in construction sector: residential construction, non-residential building construction, repair construction and engineering construction excluding repairs. Data for engineering construction excluding repairs are not available for 1997-2001. * 1981-1997; ** 1989-1997

6 There was very large variation in output per hour growth in the components of the engineering construction sub-industry. Over the 1961-2001 period the communications engineering enjoyed by far the most rapid labour productivity growth (2.6 per cent per year), followed by electric power engineering (1.7 per cent), transportation engineering (1.0 per cent), other engineering (0.7 per cent), and oil and gas engineering (-0.4 per cent).

productivity gains, a possible failure to adjust construction output for quality improvements, and strong growth in the capital-labour ratio in construction.

Use of input cost deflators

The evidence suggests that Statistics Canada is overestimating the increase in the prices (inflation) of output produced by the construction industry, because it is using deflators based on the cost of inputs instead of the price of outputs. This overestimation of the increase in output prices is the strongest evidence that Statistics Canada's estimates of construction labour productivity growth may exhibit downward bias. US researchers have identified a similar problem with US construction productivity statistics. Simply put, the faster prices rise, the more Statistics Canada must adjust downward (deflate) its estimates of output growth and productivity growth. If Statistics Canada overestimates the rise in prices, then it will underestimate real output and productivity growth.[7]

The fundamental difficulty faced by those who attempt to measure the output of the construction industry, in real terms, is the heterogeneous and complex nature of that output; almost every project in construction is unique. Trying to find a uniform measure of the quality of construction projects is exceedingly difficult. Square footage is the most common proxy measure of quality in construction project, but size alone is an inadequate measure of quality change. For instance, one house might be very large, yet have low quality fittings, while another may be smaller and have better quality fittings. Square footage is not a perfect proxy for quality. Determining what proportion of the increase in the price of a construction project is caused by improved quality, and what proportion is caused by other factors, is difficult, since no two construction projects, especially over time, are exactly the same.

Historically, this difficulty has often led to input-cost based measures of price change being used to deflate construction output. Input cost indexes measure the changing cost of the inputs used in construction projects. However, to generate an accurate measure of real output growth using an input-cost based deflator, two assumptions must hold: both productivity and profit margins must be constant. Essentially, use of an input cost index to deflate output assumes that the price of output moves in step with the price of inputs. Producing more output for a given amount of input is the definition of productivity growth. Even if input prices are rising, output prices may rise more slowly, or even fall, since less input is needed to produce a given amount of output. If productivity growth is taking place, then an input cost index will tend to grow faster than an output price index. If this input cost index is then used to deflate output, the amount of real output will be understated. Furthermore, input cost indexes often use weights for constit-

7 Statistics Canada assigns a rating of moderately reliable to the Fisher volume index of value added in the construction sector and a rating of reliable to labour input. This implies that labour productivity would be rated at least moderately reliable, which may suggest that mismeasurement is not a major problem. See Beckstead, Girard and Harchaoui (2001) who provide a detailed assessment of data quality for Statistics Canada's productivity program at the P level (122 industries), the M level (46 industries) and the S level (16 industries) of industry aggregation. Construction is one industry at all three levels. They assign three rankings (1 for reliable, 2 for moderately reliable, and 3 for unreliable) for Fisher volume indices of aggregation KL, Fisher volume indices for aggregation KLEMS, and inputs costs in current dollars of aggregation KLEMS. In terms of Fisher volume indices of aggregation KL, they assign a rating of reliable to capital, labour, and combined inputs and a rating of moderately reliable to value added and multifactor productivity. In terms of Fisher volume indices of aggregation KLEMS, they assign a rating of reliable to capital, labour, services, combined inputs, and multifactor productivity, a rating of moderately reliable to materials, and a rating of unreliable to energy. In terms of the inputs cost in current dollars of aggregation KLEMS, they assign a rating of reliable to capital, labour, materials, service, total costs of inputs, and a rating of moderately reliable to energy.

uent inputs that remain fixed for long periods of time. Fixed weights do not allow for the inevitable changes in input mix resulting from technological change. Making the assumptions about productivity growth, profit margins, and the relative weights of different inputs in construction, that are required to use input-cost based deflators, can lead to the mismeasurement of productivity growth.

Two key questions that this article seeks to answer are to what extent is Statistics Canada relying on input cost indexes to deflate construction output, and is the use of such input cost indexes resulting in underestimation of real output growth, and therefore productivity growth, in the Canadian construction industry.

Statistics Canada uses both output price indexes and input cost indexes to deflate construction output.[8] A particular type of price index used by Statistics Canada is called a model price index. A model price index avoids the problem of output heterogeneity by holding constant over time a detailed specification for a structure or different components of a structure. On a regular basis, construction firms or informed individuals, such as cost-engineers or contractors, are asked to estimate the selling price of the model or components of the model. In this way, the pure price change can be observed, while quality is held constant. Examples of model price indexes developed and used by Statistics Canada in the estimation of construction industry productivity are the "New Housing Price Index," the "Apartment Building Construction Price Index," and the "Non-Residential Building Construction Price Index."[9]

Statistics Canada also widely uses input cost indexes to deflate construction output. There are several justifications for doing so. First, input cost indexes are often "very simple and the least expensive to construct and maintain" (Mohammadian and Seymour, 1997:2). Input-cost based deflators are usually a weighted average of a wage labour index and a building materials index. Input cost indexes can be created by statistical agencies from records collected from businesses on a regular basis, such as union wage rate agreements or the selling prices of materials used in construction like cement, engineered lumber, or electrical wiring. Second, when no alternative is available, using input cost indexes is better than using no deflator at all. Finally, it is arguable that using input cost indexes could be superior to using a price index, if the price index were only distantly related to the output being deflated. However, none of these justifications reduce the potentially serious error that deflation using input cost indexes can impart to productivity estimates.

All nominal output in the engineering construction industry in Canada is deflated using deflators constructed from input cost indexes. Statistics Canada uses three separate deflators to deflate all of engineering construction, a highway construction deflator, a railway construction deflator, and a deflator for all other output of the engineering construction industry. The Income and Expenditure Accounts Division of Statistics Canada is currently developing separate deflators for each of the components of engineering construction, so that they can be deflated separately, instead of using the aggregate approach. Statistics Canada believes this project will result in a better deflator for engineering construction output.[10] Examples of input cost indexes that are used by Statistics Canada to estimate construction industry productivity are the "Construction Union

8 Hedonic and bid-price indexes are discussed in the unabridged version of this article. However, since they are not particularly relevant for construction analysis in Canada, they are not discussed here.

9 For an extensive discussion of these model price indexes, see the unabridged version of this article (Harrison, 2007).

10 This information is based on conversations with Statistics Canada officials.

Wage Rates Index" and "Industrial Products Price Index."[11]

The Construction Union Wage Rate Index has a 40 per cent weight in the deflator used to deflate the alterations and improvements component of residential construction. Indirectly, it is also used to deflate part of repair construction, because repair construction is deflated using an implicit price index based on the alterations and improvements component of residential construction. The Industrial Products Price Index (IPPI) tracks the prices of major commodities sold by manufacturers in Canada. Data are collected using a sample survey of manufacturers and other surveys. Prices are measured "at the factory gate" and, therefore, represent what the manufacturer receives, not the price that is paid by the purchaser. Factory gate prices exclude indirect taxes like sales taxes and tariffs and exclude service costs of transporters, wholesalers and retailers where applicable.

The IPPI is the basis for a residential material price index,[12] which is given a weight of 60 per cent in the deflator used to deflate the alterations and improvements component of residential construction. Indirectly, it is also used to deflate part of repair construction, because repair construction is deflated using an implicit price index based on the deflator for the alterations and improvements component of residential construction.

Appendix 1 shows that approximately 60 per cent[13] of value added in the construction industry in Canada is deflated using input-cost based deflators for intermediate goods and gross output. Given the known problems with using input-cost based deflators, it seems reasonable to hypothesize that a significant proportion of construction industry value added is being over-deflated, and, therefore, real output is being underestimated. This section will examine the evidence that is available to support (or refute) this hypothesis.

If input-cost based deflators used in the construction industry impart a downward bias to productivity estimates, we would expect to see a more rapid rate of growth in those deflators when compared with deflators based on output price indexes *ceteris paribus*. The deflators used by Statistics Canada to deflate the nominal value of gross output in the engineering, repair and other construction activities sub-industries are based entirely on input cost indexes. On the other hand, the deflator used to deflate non-residential building construction gross output is almost entirely based on output price indexes.

The implicit deflator for engineering, repair and other construction activities, which is input-cost based, increased much more rapidly, on average at 2.71 per cent annually between 1981 and 2003, than the implicit deflator for nonresidential construction, which increased at 1.78 per cent annually (Chart 7). This finding is consistent with the hypothesis that the input-cost based deflators impart downward bias to productivity estimates.

What might be the impact of this bias on the growth rate of productivity in the construction industry? There is a difference of 0.93 percentage points between the average rate of growth of the implicit deflator for engineering, repair and construction activities, which is based almost entirely on input cost indexes, and the implicit deflator for non-residential building construction, which is based almost entirely on output price indexes. Let us assume that the implicit deflator for engineering, repair and other con-

11 For an extensive discussion of these input cost indexes, please refer to the unabridged version of this article.

12 This "residential material price index" which is based on the IPPI should not be confused with Statistics Canada's Residential and Non-Residential Building Material Price Indexes which were maintained monthly between January 1981 and June 1990, at which point they were terminated.

13 Based on 2003 figures. See Appendix Table 1.

struction activities has risen more quickly than it would have if it were based on output price indexes. Therefore, output in engineering, repair and other construction activities is over-deflated. Then the deflator used to deflate non-residential building construction, which is based almost entirely on the Non-Residential Building Construction Price Index, could be applied to engineering, repair and other construction activities to provide a more accurate measure of productivity growth.

Let us conduct a brief experiment to see the impact of a change in the use of deflators. First, we calculate the implicit deflator for total construction as a weighted average of the deflators and output weights of the main component sub-industries (Equation (1)):

(1) Total construction implicit deflator (1981-2003) (2003 output weights)

=

(Output weight of residential construction)*(implicit deflator growth rate for residential construction)

+

(Output weight of non-residential building construction)*(implicit deflator growth rate for non-residential building construction)

+

(Output weight of engineering, repair and other construction activities)*(implicit deflator growth rate for engineering, repair and other construction activities)

= (0.3387)*(2.77) + (0.1732)*(1.78) + (0.4750)*(2.71)

= 2.53

Therefore, we will assume that the growth rate of the implicit deflator for total construction is 2.53 per cent per year. If we now replace the implicit deflator growth rate for engineering, repair and other construction activities with that of non-residential building construction, and recalculate equation (1) we obtain

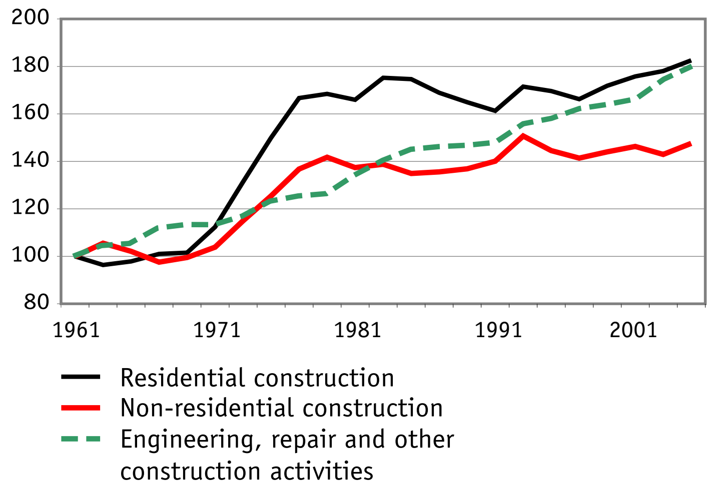
(2) Total construction implicit deflator (1981-2003) (2003 output weights)

= (0.3387)*(2.77) + (0.1732)*(1.78) + (0.4750)*(1.78)

= 2.09

Chart 7

Implicit Deflators for Residential, Non-Residential and Engineering and Repair Construction, 1981-2003



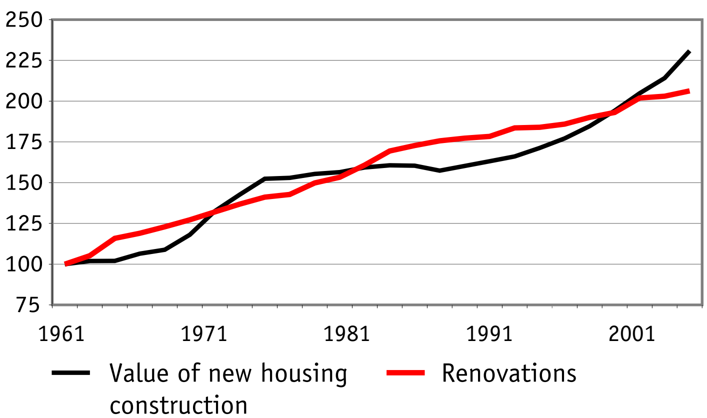
Compound Annual Growth Rates: 1981-2003 (per cent)

Residential Construction	2.77
Non-Residential Construction	1.78
Engineering, repair and other construction activities	2.71

Source: Statistics Canada CANSIM Tables 379-0023 and 379-0017.

Equation (2) shows that a 0.44 percentage-point decrease in the average growth rate for the overall construction deflator would result from a downward adjustment to the implicit deflator for engineering, repair and other construction activities. How would this adjustment impact productivity growth rates? The growth rate of productivity in the overall business sector between 1981 and 2006 was 1.46 per cent. The productivity growth rate in the construction industry was 0.53 per cent. The difference between the two was 0.93 percentage points. As an upper bound estimate of possible over-deflation of construction industry output, 0.44 points (47 percent) of this gap could be explained. If this situation were true, then construction industry productivity growth would have averaged 0.97 per cent per year rather than 0.53 per cent.

Chart 8
Implicit Deflators for the Value of New Housing Construction and the for Renovations, 1981-2006, Canada



What, however, is to be made of the 2.77 per cent annual growth rate in the implicit deflator for residential construction. Given that approximately two-thirds of value added in residential construction is deflated using output price indexes, why has the implicit deflator shown more rapid growth than the input-cost based deflator used in engineering, repair and other construction activities? Could it be that the input-cost based deflator used to deflate the renovations component of residential construction is biased upward? The evidence suggests that this is not the case (Chart 8). In fact the implicit deflator for the value of new housing rose slightly more rapidly, at 3.40 per cent per year, than the implicit deflator for renovations, which rose at 2.94 per cent per year.

There are two observations that can be made about the relative paths taken by the output-price and input-cost based deflators. The first note is that in both the case of the implicit deflator for renovations (Chart 8) and the implicit deflator for engineering, repair and other construction activities (Chart 7), the growth pattern tended to be less variable than the growth paths of the deflators based on output prices. This phenomenon is the result of input costs generally being more stable than output prices. Indeed, input cost indexes tend almost never to fall. The second point of note is that the implicit deflators for residential and non-residential building construction increased greatly between 1985 and 1990, and then only increased slightly between 1990 and 2003 (Chart 8). At the same time, the implicit deflator for engineering, repair and other construction activities steadily increased throughout the 1980s and 1990s.

While there is some evidence that input-cost based deflators are overstating the rise in real value added in the construction industry in Canada, the evidence available is conflicting. While the implicit deflator for engineering, repair and other construction activities, based on input cost indexes, grew significantly faster than the output-price based implicit deflator for non-residential building construction, the input-cost based implicit deflator for renovations grew slightly less rapidly than implicit deflator for new housing, which is based almost entirely on output price indexes.

In Canada, deflators used in the construction industry that are based on the costs of inputs (e.g. concrete, labour, wood products) have generally increased faster than those based on output prices (e.g. houses warehouses, roads). For example, the input cost indexes used to deflate nominal output in engineering and repair construction, advanced at a 2.71 per cent average annual rate over the 1981-2003 period. In contrast, the output-price based deflator used to deflate the nominal output of non-residential building construction advanced at only a 1.78 per cent average annual rate, a difference of 0.93 percentage points. Given that engineering and repair construction represent about 48 per cent of total construction GDP, this in turn would increase output per hour growth in the overall construction industry by 0.44 percentage points per year, from around 0.53 per cent to 0.97 per cent. Thus an upper bound estimate on the role of measurement error in construction productivity growth would be 0.44 percentage points, which accumulates to a significant number over such a long period. This estimate of the measurement error assumes that changes in output prices for engineering and repaid construction can be reasonably proxied by changes in output prices in non-residential building construction. The paper does not argue that these assumptions are valid. Therefore, the estimate of the upper-bound of measurement error should be seen a suggestive and of an order of magnitude only.

Strong construction productivity gains in other countries[14]

It is not inevitable that construction productivity growth be weak. Labour productivity growth in the construction industry in many countries was above 1.5 per cent per year over the 1979-2003 period (Chart 9). The UK construction industry, for example, experienced output per hour growth of 1.9 per cent per year. This situation may suggest that, if properly measured, construction productivity growth can be robust and that Canada's poor productivity performance may reflect mismeasurement. Of course, other factors might also account for faster construction productivity growth in other countries so the use of large differences in productivity performance across countries to support the mismeasurement hypothesis is not conclusive.

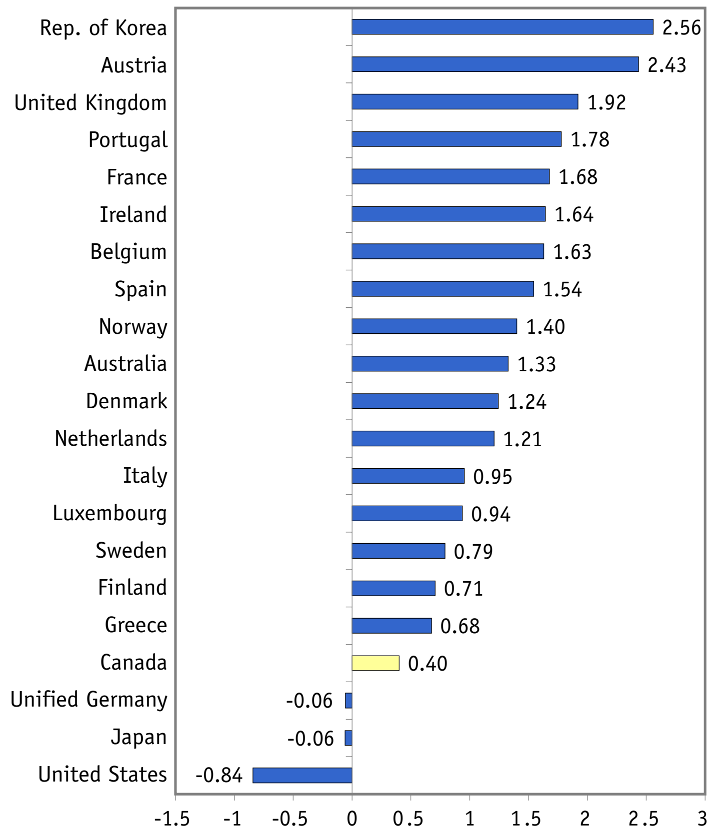
Significant task-based productivity gains

Task- or activity-based productivity measurement involves measuring the change over time in the number of hours required to complete a specific task, e.g. installing 10 square metres of ceiling tile. If the number of hours required to perform the task falls, then all else being equal, productivity has improved.

Chart 9

Labour Productivity Growth Rates, Construction Industry, 1979-2003

(per cent)



Source: Harrison (2007:Appendix Table 3).

Note: Average annual growth rates for countries without data available for 2003, such as Japan, Korea and Norway, are calculated for the period 1979-2002.

Construction sector is defined according to the International Standard Industrial Classification (ISIC-rev.3.) category 45.

Both the literature on productivity measurement in the construction industry[15] and the construction practitioners interviewed for this project[16] provided strong evidence that on a task basis there have been significant productivity gains in construction. For example, practitioners cited labour-saving improvements in mate-

14 Data for this section are drawn from the Groningen Growth and Development Centre, 60-Industry Database as of March 2007 and available at http://www.ggdc.net. This source is used since the data are classified according to the International Standard Industrial Classification (ISIC), which makes industries comparable across countries.

15 See the unabridged version of this article for an extensive survey of the literature on construction productivity (Harrison, 2007).

rials, like engineered wood flooring over traditional hardwood flooring, and significant improvements in machinery used for hoisting and earth moving. Given the large number of construction tasks that many argue experienced gains, one might have expected that this would have translated into stronger productivity growth at the level of the industry and that the failure of such gains to appear is due to the inability of the statistical system to capture them because of measurement problems.

The counter-argument is that the number of tasks with significant productivity gains may not have been particularly large, and therefore one would not expect a major impact on the overall rate of productivity growth in the construction industry. Moreover, at least one practitioner noted that productivity growth could be slow due to a lack of significant improvement in management and organization coupled with the increasing complexity of projects.

Failure to adjust construction output for quality improvements

It is recognized that price indices should be adjusted to take account of quality improvements, and that such adjustments can lead to much lower price increases and larger real output increases. This has been the case in the computer industry where massive quality improvements in computers have resulted in plummeting quality-adjusted prices and soaring real output. While the quality improvements in the output of the construction industry are certainly much less than in the computer industry, the construction industry practitioners interviewed for this study identified a significant number, such as more energy efficient buildings and lower-maintenance structures. If Statistics Canada has not made sufficient downward adjustment in construction price indexes to reflect these quality improvements, then real output and productivity may be underestimated.

Strong growth in capital-labour ratio in construction

A key driver of labour productivity is the increase in the capital stock with which each worker works. The rate of growth of the capital-labour ratio in the construction industry in Canada has been strong, averaging 2.57 per cent per year over the 1987-2004 period and above the business sector average. Yet this increased capital intensity of production of the industry has not translated into labour productivity gains, which is surprising and a different result from that found in other industries. This may suggest that measurement error is at play.

Evidence Not Supporting the Mismeasurement Hypothesis

Evidence not supporting the mismeasurement hypothesis includes weak construction productivity growth observed in other countries, rapid productivity growth in earlier periods, large provincial differences in construction productivity growth, the lack of evidence of a failure to capture the underground economy, and the lack of an effect of prework on construction productivity.

Weak construction productivity growth in other countries

It could be the case that labour productivity growth is inherently weaker in construction because of the one-off nature of much construction output. A large number of countries experienced very weak labour productivity growth in the construction industry over the 1979-2003 period (Chart 9). For example, the United States saw an average annual decline of 0.8 per cent in

16 The members of the Labour Market Information Committee of the Construction Sector Council were interviewed in February 2006 to ascertain the views of experienced industry practitioners on construction productivity trends. See the unabridged version of the report (Harrison, 2007) for the results of the survey.

output per hour, and both Japan and Germany experienced slightly negative productivity growth in the construction industry. Of course, measurement problems might account for the dismal construction industry productivity performance in these countries. But to the degree that the statistical systems of these countries are better at capturing true productivity gains than the Canadian statistical system, this situation may be due to the reality that productivity growth in construction is fundamentally slower than in other industries because of the labour-intensive nature of many construction tasks, which are not amenable to mechanization.

Earlier periods of rapid construction productivity growth in Canada

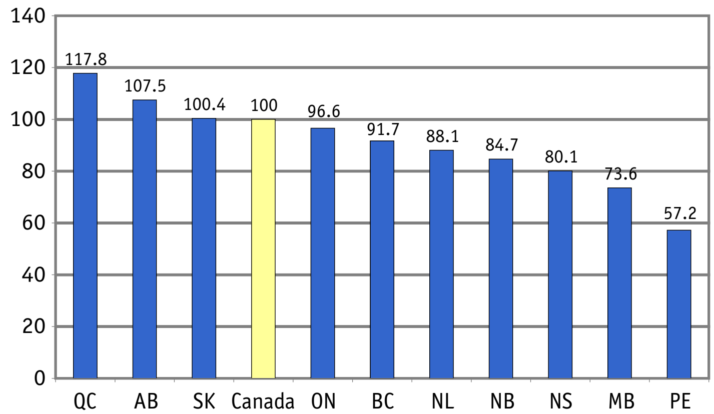
Labour productivity in the construction industry in Canada advanced at the phenomenal rate of 5 per cent per year between 1974 and 1983. This suggests that our statistical system was fully capable of capturing construction productivity gains in the past, and the fact that since 1983 it has recorded only weak gains suggests that they may just not be there to be recorded. Of course, measurement problems could have been at play in both periods. At the same time, evidence suggests that Statistics Canada did alter its measurement techniques for construction prices in the 1980s and 1990s. While outside the scope of his article, more research is required to determine how changes over time in the measurement techniques used by Statistics Canada have affected productivity estimates for the construction industry.

Large provincial differences in construction productivity growth

While current dollar GDP per hour worked in the construction industry in 2003 in Canada as a whole was $33.03, this performance masked wide variations in construction productivity levels among provinces (Chart 10).[17] Quebec showed by far the highest productivity with a value of per hour output of $39.91 (117.8 per cent of the national average), while the lowest productivity was observed in Prince Edward Island, at $18.89 (57.2 per cent of the national average). Alberta showed the second highest level of productivity, while Manitoba and Nova Scotia had relatively low levels of productivity. The other provinces fell somewhere in between, most approximately between $28.00 and $33.00 of output per hour.

Turning to growth rates in constant dollar GDP per hour worked, on a provincial basis, the diversity across provinces is even more pronounced than in levels (Chart 11). In the 1987-2005 period, construction industry productivity in Canada rose at a compound annual rate of 0.08 per cent. Five provinces exhibited negative growth rates over the period, while five showed positive growth rates. The poorest performers

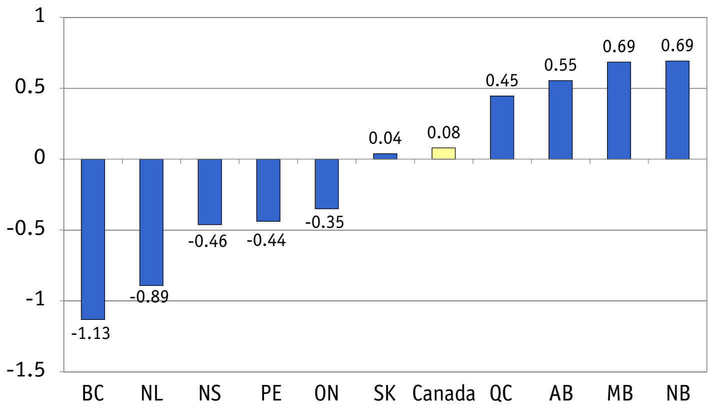
Chart 10
Labour Productivity by Province as a Percentage of Canada's Labour Productivity in Construction Industry, 2003
(current dollars)



Source: Calculated by CSLS from Statistics Canada CANSIM II table 379-0025 and 383-0010.

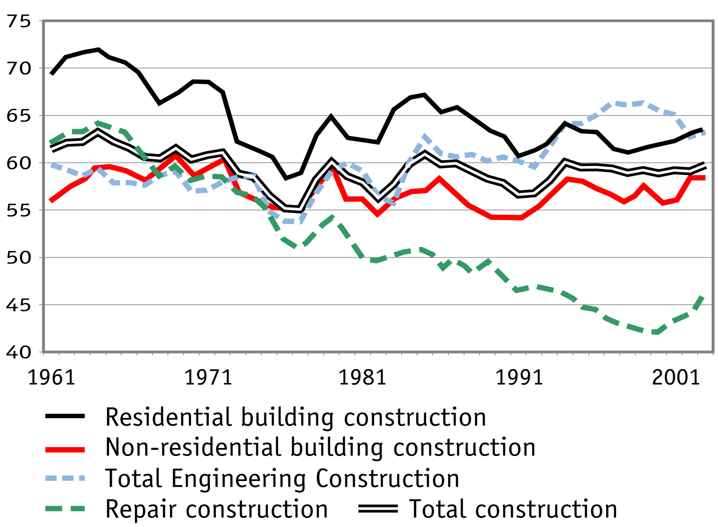
17 Data on output per hour by province is in terms of value productivity, not in terms of physical productivity, since estimates of purchasing power parity prices for the construction industry across provinces are not available.

Chart 11
Labour Productivity (real GDP per hour) Growth, 1987-2005
(per cent)



Source: CSLS Database: Labour, Capital and Total Factor Productivity by Industry for Canada and the 10 provinces: http://www.csls.ca/data.asp. Tables S1 and S7.

Chart 12
Value of Intermediate Goods as a Proportion of Gross Output, Major Construction Sub-industries, Canada, 1961-2003
(per cent)



Source: Compiled by the CSLS from Statistics Canada CANSIM Tables 379-0023 and 381-0009.

were British Columbia (-1.13 per cent) and Newfoundland (-0.89 per cent). Nova Scotia (-0.46 per cent), Prince Edward Island (-0.44 per cent) and Ontario (-0.35 per cent). The highest compound annual growth rate (0.69 per cent) was observed in New Brunswick and Manitoba, with Alberta (0.55 per cent), Quebec (0.45 per cent) and Saskatchewan (0.04 per cent) also showing positive productivity growth.

These differences between provinces suggest that factors other than measurement problems may be at play in explaining construction productivity growth. Of course, both measurement problems and other factors may be at work. Differences across provinces are not inconsistent with measurement problems.

Lack of evidence of a failure to capture the underground economy

It is widely recognized, including by all industry practitioners who we surveyed, that much construction activity is not reported to the taxation authorities. But this does not mean that these transactions are not included, through imputations, in the estimates of nominal output for the construction industry produced by Statistics Canada. Indeed, our detailed analysis of the procedures used by Statistics Canada to estimate the nominal output of the industry suggests that the lion's share of underground activity is accounted for and that nominal output is not underestimated. However, because of the clandestine nature of underground activity, one cannot say with full certainly that this is the case, but is unlikely that underground activity is the cause of mismeasurement.

The possibility of a large-scale underestimation of gross output in the construction industry is thus very small in Canada. This results directly from the method used to estimate gross output in the industry, which relies mainly on demand-side indicators rather than supply-side indicators. While contractors in the construction industry have strong incentives to underreport, consumers' incentives to do so are much lower. Though it is still possible that there is some underestimation of gross output in the construction, this underestimation, even under a worst-case scenario, cannot account for much of the weakness in the construction sector productivity growth.

The lack of effect of prework on construction productivity

The greater use of prework[18] in the construction industry, while resulting in productivity gains in terms of overall labour requirements for construction projects, has no *a priori* effect on output per hour in the construction industry itself and, therefore, cannot account for mismeasurement of productivity gains. During the interviews with construction industry practitioners, it also became clear that there was considerable uncertainty as to whether prework was taking place in the construction industry or the manufacturing industry. Most respondents believed that prework, regardless of where it was carried out should constitute part of the construction industry.

Another reason why prework is unlikely to be mismeasured is the stability of the ratio of current dollar intermediate goods to gross output. This stability suggests that the relative importance of prework has not been increasing over time in Canada.

Conclusion

This article makes a case that measurement error may account for much of the weakness in labour productivity growth in the construction industry in Canada over the last quarter century. It is argued that the use by Statistics Canada of input cost deflators in the deflation of the nominal value of output in a number of construction sub-industries introduces a significant downward bias into productivity estimates. A ballpark estimate of the upper bound of this bias is 0.44 percentage points per year over the 1981-2006 period. This would raise output per hour growth in the construction industry from 0.53 per cent to 0.97 per cent and would eliminate about one half of the gap in labour productivity growth between the construction industry and the overall business sector. It is important to stress that the estimates should be seen as suggestive and of an order of magnitude only.

References[19]

Beckstead, Des, Andrée Girard and Tarek Harchaoui (2001) "Assessing the Data Quality of Statistics Canada's Productivity Program," in *Productivity Growth in Canada*, cat. 15-204-XIE, Statistics Canada.

Centre for the Study of Living Standards (2001) "Productivity Trends in the Construction Sector in Canada," report prepared for Canada Mortgage and Housing Corporation, CSLS Research Report 2001-3, November.

18 Unfortunately, there appears to be a lack of clarity about the precise definition of prework and of its components: modularization, prefabrication, and preassembly. The term *industrialization* has also been used in reference to pre work, for example Finn (1992), but following Haas *et al.* (2000) this study does not use that term. Therefore, it is worth briefly clarifying what is meant by these terms as used in this study. Following Haas *et al.* (2000), a study completed by the Center for Construction Industry Studies at the University of Texas at Austin, the components of prework are:

Modularization: construction of a complete system away from the job site which is then transported to the site. Modules may be too large to transport in one piece, and, therefore, may need to be broken down into smaller pieces for transport.

Prefabrication: Tatum (1987) defines prefabrication as "a manufacturing process, generally taking place at a specialized facility, in which materials are joined to form a component part of a final installation." Haas *et al.* (2003:3-4) add that prefabrication "normally involves one skill or trade, such as electrical, piping, or rebar" and that "any component that is manufactured offsite and is not a complete system can be considered prefabricated."

Preassembly: Preassembly is a combination of prefabrication and modularization. It involves the assembly of materials and prefabricated components at the jobsite or somewhere else. Preassembly often involves the work of numerous trades and usually only involves part of a system. Preassembled work is installed in a manner similar to the installation of modules (Haas *et al.,* 2000:4).

19 A complete bibliography is included in the unabridged version of this article.

Finn, D.W. (1992) "Towards Industrialized Construction," *Construction Canada*, Vol. 34, pp.25-26, 28, May.

Harrison, Peter (2007) "Can Measurement Error Explain the Stagnation of Productivity Growth in the Canadian Construction Sector in Canada?" CSLS Research Report 2007-4, April, report prepared for the Canadian Construction Association. (Ottawa: Centre for the Study of Living Standards).

Haas, Carl T., James T. O'Connor, Richard L. Tucker, Jason A. Eickmanm, Walter R. Fagerlund. (1999) "Prefabrication and Preassembly Trends and Effects on the Construction Workforce." Austin: University of Texas at Austin, Center for Construction Industry Studies, Report no. 14.

Mohammadian, Rasool and Stan Seymour (1997) "An Analysis of Some Construction Price Index Methodologies," Prices Division Analytical Series, cat. no. 62F0014MIB -No. 2, Statistics Canada, April.

Sharpe, Andrew (2001) "Productivity Trends in the Construction Sector in Canada," *International Productivity Monitor*, Number Four, Fall pp. 54-67.

Statistics Canada (2001a) *A Guide to Deflating the Input-Output Accounts: Sources and methods.* Statistics Canada Catalogue no. 15F0077GIE. System of National Accounts.

Statistics Canada (2001b) "Innovation, Advanced Technologies and Practices in the Construction and Related Industries: National Estimates," Science, Innovation and Electronic Information Division, February.

Statistics Canada (2002) *Gross Domestic Product by Industry – Sources and Methods,* Statistics Canada Catalogue no. 15-547-XIE.

Statistics Canada (2005) *Capital Expenditure Price Statistics*, *First Quarter 2005*, Statistics Canada Catalogue no. 62-007-XPB.

Tatum, C.B., Vanegas, J. A., and Williams, J. M. (1987) "Constructability, Improvement Using Prefabrication, Preassembly, and Modularization," Construction Industry Institute, The University of Texas at Austin.

Appendix 1: Statistics Canada Methodology for Estimation of Construction Value Added

Because of inflation, in order to determine the real change in output, nominal (current-dollar) output must be converted to real (constant-dollar) output by use of a deflator.[20] A deflator is a number by which nominal output is divided in order to produce real output. Once deflated, a real output series should measure only the change in the volume of output. Real value added is calculated using what is called the double-deflation methodology. This procedure involves deflating separately the value of gross output and the value of intermediate inputs by appropriate deflators. Real value added is then calculated residually as the difference between the two series.

In the Input-Output tables construction is divided into eight special industry aggregations also known as commodities: Residential; Non-residential building; Transportation Engineering; Gas and oil engineering; Electric power engineering; Communications engineering; Other engineering; and Repair construction. These commodities are then deflated using deflators developed by the Income and Expenditure Accounts Division of Statistics Canada. (Statistics Canada, 2001a:35) Deflators are constructed to deflate specific series. For example, there are separate deflators for apartment buildings and for shopping malls. The price indexes that are used to construct deflators and the deflators themselves will be examined in detail below. It is in the construction of deflators for output that a potential problem of productivity measurement arises.

Appendix Table 1 summarizes the deflators currently used to deflate different commodities pro-

20 For an extensive discussion of how Statistics Canada calculates nominal output in the construction industry, including an extensive discussion of estimations on the underground economy in construction, please refer to the unabridged version of this article.

Appendix Table 1
Summary of Construction Deflator Methodologies

Commodity/Industry (NAICS/IOIC-based)	Deflation Method	Type of Deflator	Share of total Construction Industry Value Added in 2003, current dollars, (per cent)[2]	
Residential Building Construction				
Single dwellings, semi-detached dwellings, and row housing	New Housing Price Index (NHPI)	Output (model) price index	23.77	33.87
Apartments	Apartment Building Construction Price Index (ABCPI)	Output (model) price index		
Alterations and improvements to existing housing (renovations)	Residential building materials index, (60% Industrial Products Price Index, 40% Construction Union Wage Rates Index)[1]	Input cost index	10.10	
Non-Residential Building Construction	Non-Residential Building Construction Price Index (NRBCPI) with an adjustment of 10 per cent for own-account construction	Output (model) price index	17.32	
Transportation Engineering Construction (SIC: Road, highway and airport runway construction)	Highways and roads are deflated by a specific index, airport runway construction is deflated using the aggregate deflator for engineering construction excluding highways and railways	Input cost index	4.90	
Oil and Gas Engineering Construction (SIC: Gas and oil facility construction)	Aggregate deflator for engineering construction excluding highways and railways	Input cost index	11.61	
Electric Power Engineering Construction (SIC: Dams and irrigation projects)	Aggregate deflator for engineering construction excluding highways and railways	Input cost index	5.48	
Communications Engineering Construction (SIC: Railway and telecommunications construction)	Railways are deflated by a specific input cost index, telecommunications construction is deflated using the aggregate deflator for engineering construction excluding highways and railways	Input cost index	0.75	
Other engineering construction	Aggregate deflator for engineering construction excluding highways and railways	Input cost index	5.38	
Repair Construction	Implicit price index for alterations and improvements component of residential construction	Implicit price index based on input cost index	19.39	

Notes:

1 The weighting used in the deflator for Alterations and Improvements to residential structures is derived from the Homeowner Repair and Renovation Survey.

2 Shares do not sum to 100 because "Other activities of the construction industry," which account for 1.31 per cent of output do not appear in this table at this time.

Sources: Centre for the Study of Living Standards, based on discussions with Statistics Canada officials and Statistics Canada (2001a:35-36)

duced in the construction industry. In order to generate real value added, the corresponding deflator is used to deflate each of these commodities.

Residential building construction

Residential building construction is subdivided into three principal components for deflation purposes. The first component includes single-family dwellings, semi-detached dwellings, row houses, and cottages. This component is deflated using the New Housing Price Index. The second major component is apartment building construction, which is deflated using the Apartment Building Construction Price Index. The third substantial component of residential construction is renovations. Renovations are deflated using a specially constructed wage and materials cost index. The Construction Union Wage Rates Index is given a weight of 40 per cent in the deflator and a special construction materials index is given a weight of 60 per cent. Several other minor components of residential construction are deflated in a variety of ways.

Residential building construction accounted for 33.87 per cent of all construction industry value added in 2003. Within residential construction, 23.77 per cent of total construction value added was derived from single-family dwellings, semi-detached dwellings, row houses, cottages, and apartment building construction, and was deflated using output prices. Alterations and improvements (renovations), deflated using an input-cost based deflator constituted 10.10 per cent of total construction value added.

Non-residential building construction

Non-residential building construction is deflated by the Non-Residential Building Construction Price Index, which is an output-price based deflator based on the model price method. Contracted investment is given a weight of 90 per cent and own-account work a weight of 10 per cent. Own-account construction work is deflated using a fixed-weighted index based on the Survey of Employment, Payroll and Hours (SEPH) for earnings in the construction industry, materials prices based on the Industrial Products Price Index, and overhead costs based on various prices indexes. Non-residential building construction made up 17.32 per cent of total construction industry value added in 2003.

Engineering construction

Engineering construction is deflated in three components. The first two are highway construction and railway construction. Each is deflated by a specific input-cost-index based deflator. The remaining component of engineering construction is also deflated using a different input-cost-index based deflator. These deflators are based are on a composite of wage, materials and overhead costs. The weights accorded to each of the three components were derived from the 1997 Input-Output tables. The wages component is based on the SEPH. These prices are not output prices. The materials component is based on the Industrial Products Price Index. The overhead costs component is based on a mix of average weekly earnings indexes and consumer price indexes. Engineering construction accounted for 28.11 per cent of total construction value added in 2003. Almost all of this output was deflated using input cost indexes.

Repair construction

Repair construction is deflated using the same cost index that is used to deflate residential renovations. Repair construction made up 19.39 per cent of total construction industry value added in 2003.

EU KLEMS Growth and Productivity Accounts: An Overview

Marcel P. Timmer[1]
University of Groningen
Mary O'Mahony
University of Birmingham
Bart van Ark
University of Groningen

Abstract

In March 2007, the EU KLEMS Growth and Productivity Accounts were publicly released. These accounts include measures of output growth, employment and skill creation, capital formation and multifactor productivity (MFP) at the industry level for European Union member states from 1970 onwards. This overview paper first discusses the key characteristics of the database and the variables, country and industry coverage, then reviews the growth accounting methodology, including the measurement of labour and capital services, and finally provides a brief analysis of major trends. The first release of the EU KLEMS database confirms the view that European countries showed a significant slowdown in productivity growth since 1995, which is shown to be widespread across countries and industries, but with notable differences.

The EU KLEMS Growth and Productivity Accounts are the result of a research project, financed by the European Commission, to analyse productivity in the European Union at the industry level. This database is meant to support empirical and theoretical research in the area of economic growth, such as study of the relationship between skill formation, investment, technological progress and innovation on the one hand, and productivity, on the other. In addition, the database may facilitate the conduct of policies aimed at supporting a revival of productivity and competitiveness in the European Union. These policies require comprehensive measurement tools to monitor and evaluate progress. The construction of the database should also support the systematic production of high quality statistics on growth and productivity using the methodologies of national accounts and input-output analysis.

The EU KLEMS Growth and Productivity Accounts include measures of output, employment and skill creation, capital formation and multifactor productivity (MFP) at the industry level for European Union member states from 1970 onwards. The input measures include various categories of capital (K), labour (L), energy (E), material (M) and service inputs (S). A major

1 Marcel Timmer is Asssociate Professor in the Department of Economics at the University of Groningen in the Netherlands and coordinates the International Productivity Program at the Groningen Growth and Development Centre. Mary O'Mahony is Professor at the Birmingham Business School at the University of Birmingham. Bart Van Ark is Professor in the Department of Economics at the University of Groningen and Director of the Groningen Growth and Development Centre. Emails: M.P.Timmer@rug.nl; m.omahony@bham.ac.uk; h.h.van.ark@rug.nl.

advantage of growth accounts is that they are embedded in a clear analytical framework rooted in production functions and the theory of economic growth. They provide a conceptual framework within which the interaction between variables can be analysed, which is of fundamental importance for policy evaluation. The measures are developed for individual European Union member states, and are linked with "sister"-KLEMS databases in the United States and Japan.

A key strength of the EU KLEMS database is that it moves beneath the aggregate economy level to examine the productivity performance of individual industries and their contribution to aggregate growth. Previous studies have shown that there is enormous variation in output and productivity growth across industries, so analysts should focus on the industry-level detail to understand the origins of the European growth process.

In this overview article we first provide a discussion of the key characteristics of the database and the variables, country and industry coverage. We then briefly introduce the growth accounting methodology, including the measurement of labour and capital services. In the final section we provide a brief analysis of some of the major trends observed from the March 2007 release of the database.

This brief overview paper will in due time be followed by more extensive reviews and research papers, which will also be available from the EU KLEMS website (http://www.euklems.net). The data series are also publicly available from that website. More information on the methodology used in EU KLEMS can be found in the document *EU KLEMS Growth and Productivity Accounts*, *Version 1.0*, *PART I Methodology*. Detailed source descriptions are given in *PART II Sources*, which are also downloadable from the EU KLEMS website.

The EU KLEMS database

Distinguishing characteristics

The methodology to derive multifactor productivity (MFP) growth rates has been firmly established since the path-breaking work of Jorgenson, Gollop and Fraumeni (1987), but in practice it has been rarely applied comprehensively, particularly in Europe. The OECD and the Groningen Growth and Development Centre maintain MFP series for aggregate OECD economies, but not at the industry level with the exception of a single study by Inklaar *et al.* (2005) including four European countries (France, Germany, the Netherlands and the United Kingdom).[2]

The main bottleneck has been the lack of available statistics on the composition of labour and capital at the industry level for a sufficient number of European countries. As a result, many studies resorted to cruder measures of output, inputs and MFP, mostly based on the OECD Structural Analysis database, STAN and its predecessor the International Sectoral Database, ISDB. These databases provide industry-level series on output, aggregate hours worked and aggregate capital stock for a limited group of countries and years, while ignoring changes in the composition of factor inputs.

However, MFP measures based on these aggregate concepts can be seriously biased. Labour input measures in EU KLEMS take account of changes in the composition of the labour force. Capital input measures include the effects of the rapid shift in investment towards Information and Communications Technology (ICT) goods in recent years. Finally, MFP measures are not only derived on a value added basis, but also on a gross-output basis by taking into account changes in the use of intermediate inputs, such as the increasing use of business services through outsourcing.

2 For OECD series, see www.oecd.org/dataoecd/27/39/36396940.xls. For GGDC series, see www.ggdc.nl/dseries/growth-accounting.shtml, described in Timmer and van Ark (2005).

The EU KLEMS database has been largely constructed on the basis of data from national statistical institutes (NSIs) and were processed by the research consortium according to agreed procedures which have been established over the past two years. These procedures were developed to ensure harmonization of the basic data, and to generate growth accounts in a consistent and uniform way. Importantly, this database is rooted in statistics from the National Accounts and follows the ESA95 framework in many respects. Cross-country harmonization of the basic country data has focused on a number of areas including a common industrial classification and the use of similar price concepts for inputs and outputs. Various series were linked in order to bridge different vintages of the national accounts according to a common methodology. Labour service input has been measured in a standardized way by distinguishing labour types in terms of gender, age and educational attainment. For these series additional material has been collected from employment and labour force statistics, to the extent that these were not part of the system of national accounts.

Capital service input has been measured using harmonized depreciation rates and common rules to deal with a variety of practical problems, such as weighting and rental rates. Importantly, capital input is measured as capital services, rather than stocks. Although the System of National Accounts (SNA) provides a classification of capital assets, it was not always detailed enough to back out ICT equipment from the investment series. Additional information has been collected to obtain investment series for these assets. In addition, the level of asset detail has been put on a comparable basis. Series on intermediate inputs are broken down into energy, materials and services using a standardized product classification. The EU KLEMS database provides data on a detailed industry level, but also provides higher level aggregates, such as total economy, market economy, market services and goods production for all variables.

Coverage of countries and variables

The first public release of the EU KLEMS database made on March 15, 2007 covers 25 EU countries (EU-25),[3] as well as Japan and the United States.[4] In general, data for 1970-2004 are available for the "old" EU-15 countries[5] and for the United States. Series from 1995 onwards are available for the new EU member states which joined the EU on 1 May 2004 (EU-10). Due to data limitations, the coverage differs across countries, industries and variables. Appendix Table 1 provides an overview of all the series included in the EU KLEMS database. The variables covered can be split into three main groups: (1) basic variables; (2) growth accounting variables and (3) additional variables.

The basic series contain all the data needed to construct single productivity measures, such as labour productivity (output per hour worked). These series include nominal, volume and price series of output and intermediate inputs, and volumes and prices of employment. Most series are part of the present European System of National Accounts (ESA 1995) and can be found in the National Accounts of all individual countries, at least for the most recent period. The main adjustments to these series were related to filling gaps in industry detail (using industry statistics) and to link

3 All member states of the EU as of 1 May 2004.

4 As yet, a Canadian sister database does not exist. Statistics Canada provides growth accounts which are set up along the same lines as in EU KLEMS. However, they have not yet been internationally harmonized, e.g. in terms of industrial classification (NAICS versus ISIC) and measurement of capital (use of common assumptions regarding depreciation patterns and rates). Given the abundant data availability at Statistics Canada, this harmonization should be relatively straightforward and it is hoped that this will be accomplished in the near future in cooperation with Statistics Canada.

5 All member states of the EU as of 1 January 1995.

series over time, in particular in those cases where revisions were not taken back to 1970 by the NSIs.

The variables in the growth accounting series are of an analytical nature and cannot be directly derived from published National Accounts data without additional assumptions. These include series on capital services, labour services, and multifactor productivity which are the heart and main aim of the EU KLEMS project. The construction of these series was based on a theoretical model of production, requiring additional assumptions which are spelled out in some detail in section three.

Finally, additional series are given which have been used in generating the growth accounts and are informative by themselves. These include, for example, various measures on the relative importance of ICT capital and non-ICT capital, and on the various labour characteristics within the EU KLEMS classification.

At the lowest level of aggregation, data were collected for 71 industries. The industries are classified according to the European NACE revision 1 classification. But again the level of detail varies across countries, industries and variables due to data limitations. In order to ensure a minimal level of industry detail for which comparisons can be made across all countries, so-called "minimum lists" of industries have been used. All national datasets have been constructed in such a way that these minimum lists are met. The minimum lists are different for particular groups of variables and time-periods. Two groups of variables can be distinguished: variables needed for the computation of labour productivity growth and unit labour cost analysis and a set of additional variables required to perform growth accounting (including gross output, intermediate inputs, labour composition and capital).

The number of industries covered include 62 for labour productivity post-1995, 48 for labour productivity pre-1995 and 31 industries for growth accounts. The industry detail for each country conforms at least to the minimum list of industries, but often more detail is available. Appendix Table 2 provides a listing of industries for which growth accounting variables are available. This list also includes higher level aggregates provided in the EU KLEMS database. Finally, data are provided for four institutional country groupings: EU-25, EU-15, EU-10 and Euro zone. To aggregate across countries use is made of industry-specific Purchasing Power Parities (PPPs).

Growth Accounting Methodology

The EU KLEMS growth accounts are based on the growth accounting methodology as theoretically motivated by the seminal contribution of Jorgenson and Griliches (1967) and put in a more general input-output framework by Jorgenson, Gollop and Fraumeni (1987) and Jorgenson, Ho and Stiroh (2005). Growth accounting allows one to assess the absolute and relative importance of labour, capital and intermediate inputs to growth, and to derive measures of multifactor productivity growth. MFP indicates the efficiency with which inputs are being used in the production process and is an important indicator of technological change.[6]

Under the assumptions of competitive factor markets, full input utilization and constant returns to scale, the growth of output in industry j can be expressed as the (compensation share)

6 Under strict neo-classical assumptions, MFP growth measures disembodied technological change. In practice, MFP is derived as a residual and includes a host of effects such as improvements in allocative and technical efficiency, changes in returns to scale and mark-ups as well as technological change proper. All these effects can be broadly summarized as "improvements in efficiency", as they improve the productivity with which inputs are being used in the production process. In addition, being a residual measure MFP growth also includes measurement errors and the effects from unmeasured output and inputs.

weighted growth of inputs and multifactor productivity (denoted by A^Y):

$$(1)\quad \Delta \ln Y_{jt} = \bar{v}^X_{jt} \Delta \ln X_{jt} + \bar{v}^K_{jt} \Delta \ln K_{jt} + \bar{v}^L_{jt} \Delta \ln L_{jt} + \Delta \ln A^Y_{jt}$$

where $\bar{v}^i$ denotes the two-period average share of input i in nominal output and $\bar{v}^L + \bar{v}^K + \bar{v}^X = 1$. Each element on the right-hand side indicates the proportion of output growth (Y) accounted for by growth in intermediate inputs (X) , capital services (K), labour services (L) and MFP (A), respectively. Accurate measures of labour and capital input are based on a breakdown of aggregate hours worked and aggregate capital stock into various components. Hours worked are cross-classified by various categories to account for differences in the productivity of various labour types, such as high- versus low-skilled labour. Similarly, capital stock measures are broken down into stocks of different asset types. Short-lived assets like computers have a much higher productivity than long-lived assets like buildings, and this should be reflected in the capital input measures. The contribution of intermediate inputs is broken down into the contribution of energy goods, intermediate materials and services.

Measurement of capital services

The availability of investment series by asset type and by industry is one of the unique characteristics of the EU KLEMS database. They are based on series obtained from national statistical institutes, allowing for a detailed industry-by-asset analysis. Importantly, we make a distinction between three ICT assets (office and computing equipment, communication equipment and software) and four non-ICT assets (transport equipment, other machinery and equipment, residential buildings and non-residential structures). ICT assets are deflated using a quality-adjusted investment deflator, except for those countries which have not yet implemented adequate quality adjustment where we used the harmonization procedure suggested by Schreyer (2002). The real investment series are used to derive capital stocks through the accumulation of investment into stock estimates using the Perpetual Inventory Method (PIM) and the application of geometric depreciation rates. Then capital service flows are derived by weighting the growth of stocks by the share of each asset's compensation in total capital compensation as follows:

$$(2)\qquad \Delta \ln K_t = \sum_k \bar{v}_{k,t} \Delta \ln S_{k,t}$$

where $\Delta \ln S_{k,t}$ indicates the growth of the stock of asset k and weights are given by the average shares of each asset in the value of total capital compensation. In this way, aggregation takes into account the widely different marginal products from the heterogeneous stock of assets. The weights are related to the user cost of each asset.

The user cost approach is crucial for the analysis of the contribution of capital to output growth. This approach is based on the assumption that marginal costs reflect marginal productivity. If the costs of leasing one euro of, say, computer assets is higher than the leasing of one euro of buildings, computers have a higher marginal productivity, and this should be taken into account. There are various reasons why the leasing costs of computers is higher than for buildings. While computers are typically scrapped after five or six years, buildings provide services for much longer periods. Besides, prices of new computers are rapidly declining and those of buildings are normally not. Hence the user cost of IT equipment is typically 50 to 60 per cent of the investment price, while that of buildings is less than 10 per cent. Therefore one euro of computer capital stock should receive a heavier weight in the growth of capital services than one euro of building stock. This is ensured by using the rental price of capital services as weights.

Measurement of labour services

The productivity of various types of labour input, such as low- versus high-skilled, will also differ. Standard measures of labour input, such as numbers employed or hours worked, will not account for such differences. Hence one needs measures of labour input which take the heterogeneity of the labour force into account in analysing productivity and the contribution of labour to output growth. These measures are called labour services, as they allow for differences in the amount of services delivered per unit of labour in the growth accounting approach. It is assumed that the flow of labour services for each labour type is proportional to hours worked, and workers are paid their marginal productivities. Then the corresponding index of labour services input L is given by:

(3) $$\Delta \ln L_t = \sum_l \bar{v}_{l,t} \Delta \ln H_{l,t}$$

where $\Delta \ln H_{l,t}$ indicates the growth of hours worked by labour type l and weights are given by the average shares of each type in the value of labour compensation. In this way, aggregation takes into account the changing composition of the labour force. We cross-classify labour input by educational attainment (high, medium and low), gender and age (15-29, 30-49, and 50 and over) with the aim to proxy for differences in work experience. This provides 18 labour categories (3*2*3 types). Typically, a shift in the share of hours worked by low-skilled workers to high-skilled workers will lead to a growth of labour services which is larger than the growth in total hours worked. We refer to this difference as the labour composition effect.

Series on hours worked by labour types are not part of the standard statistics reported by NSIs, not even at the aggregate economy level. Also, there is no single international database on skills which can be used for this purpose. For each country covered in EU KLEMS, a choice has been made to use survey data which provide the best sources for consistent wage and employment data at the industry level. In most cases this was a labour force survey (LFS), sometimes together with a earnings survey when wages were not included in the LFS. In other cases, use has been made of establishment surveys or a social-security database, or a mix of sources. Care has been taken to arrive at series which are consistent over time, which was important as most employment surveys are not designed to track developments over time, and breaks in methodology or coverage frequently occur.

Descriptive Results from the EU KLEMS Growth and Productivity Accounts[7]

The EU KLEMS database confirms the earlier observation that the growth performance of the European Union has undergone a marked change during the second half of the 1990s (O'Mahony and van Ark, 2003). Even though average annual real GDP growth of the EU-15 remained constant at 2.2 per cent, labour productivity growth slowed dramatically from 2.4 per cent in 1970-1995 to 1.4 per cent for 1995-2004 (Table 1). Even after including the significantly better productivity growth performance of the new member states of the Union, given their relatively small GDP, the labour productivity growth of the aggregate EU-25 was only slightly higher at 1.7 per cent from 1995-2004 (Table 2). This structural slowdown in productivity for the European Union as a whole is striking in the light of a comparison with the United States, where productivity growth accelerated significantly from 1.3 per cent averaged over 1970-1995 to 2.4 per cent from 1995-2004. Even in Japan, which showed an even bigger slowdown in productivity growth than Europe, productivity growth during 1995-

7 For a country-specific analysis of results from the first EU KLEMS release in March 2007, see van Ark *et al.* (2007).

Table 1

Gross Value Added, Labour Input and Labour Productivity, 1970-1995 and 1995-2004, European Union-15 (old EU-15)

	(annual average volume growth rates, in %)				Average share in total hours worked (%)	Contribution to LP growth in total industries (percentage point)
	Gross Value Added	Total persons engaged	Total hours worked	GVA per hour worked		
1970-1995						
TOTAL INDUSTRIES	2.2	0.4	-0.2	2.4	100.0	2.4
Electrical machinery, post and communication	4.2	-0.4	-0.8	5.0	4.1	0.2
Manufacturing, excluding electrical	1.8	-1.2	-1.6	3.4	21.6	0.9
Other goods producing industries	-0.2	-2.0	-2.4	2.1	20.7	0.6
Distribution services	2.7	0.8	0.3	2.4	19.5	0.4
Finance and business services	3.9	3.4	2.9	1.0	8.1	0.1
Personal and social services	2.1	2.0	1.6	0.5	8.1	0.0
Non-market services	2.8	2.1	1.6	1.3	17.8	0.2
Reallocation of labour effect						0.0
1995-2004						
TOTAL INDUSTRIES	2.2	1.2	0.8	1.4	100.0	1.4
Electrical machinery, post and communication	6.3	-0.5	-0.9	7.2	3.4	0.3
Manufacturing, excluding electrical	1.2	-0.7	-0.9	2.1	16.4	0.4
Other goods producing industries	1.4	-0.2	-0.5	1.9	14.5	0.3
Distribution services	2.5	1.2	0.8	1.7	20.3	0.3
Finance and business services	3.6	3.6	3.3	0.3	13.5	0.0
Personal and social services	1.8	2.6	2.0	-0.2	10.8	0.0
Non-market services	1.6	1.4	1.0	0.6	21.0	0.1
Reallocation of labour effect						0.0

Source: EU KLEMS Database, March 2007, http://www.euklems.net.

2004 was still higher than in the EU at 1.8 percent. When looking at the market economy only, the forging ahead of the United States becomes even more pronounced.[8]

However, the EU KLEMS database documents a wide variation in productivity growth rates across EU member states. Among the "old" member states the fastest productivity growth rates were recorded in Finland and Sweden.[9] Among the larger countries in the "old" EU, the UK has shown the fastest productivity growth since 1995, ahead of France and Germany. At the lower end of the productivity ranks are the two large countries in the southern part

8 The market economy excludes health (ISIC industry N), education (ISIC M) and government sectors (ISIC L). We also exclude real estate (ISIC 70), because output in this industry mostly reflects imputed housing rents rather than sales of firms.

9 Greece and Ireland also showed rapid productivity growth but, just as in the new member states, this largely reflects "catching up" growth.

Table 2

Gross Value Added, Labour Input and Labour Productivity, 1995-2004, European Union-25 (EU-25)

	(annual average volume growth rates, in %)				Average share in total hours worked (%)	Contribu-tion to LP growth in total industries
	Gross Value Added	Total persons engaged	Total hours worked	GVA per hour worked		
1995-2004						
TOTAL INDUSTRIES	2.3	1.0	0.6	1.7	100.0	1.7
Electrical machinery, post and communication	6.6	-0.4	-0.7	7.2	3.4	0.3
Manufacturing, excluding electrical	1.4	-0.9	-1.1	2.5	16.8	0.5
Other goods producing industries	1.3	-0.5	-0.7	2.0	17.2	0.4
Distribution services	2.6	1.1	0.6	2.0	20.2	0.4
Finance and business services	3.8	3.7	3.4	0.4	12.3	0.0
Personal and social services	1.8	2.5	1.9	-0.1	9.9	0.0
Non-market services	1.7	1.2	0.9	0.8	20.3	0.2
Reallocation of labour effect						0.0

Source: EU KLEMS Database, March 2007, http://www.euklems.net.

Table 3

Gross Value Added, Labour Input and Labour Productivity, 1995-2004, European Union-10 (new member states)

	(annual average volume growth rates, in %)				Average share in total hours worked (%)	Contribu-tion to LP growth in total industries
	Gross Value Added	Total persons engaged	Total hours worked	GVA per hour worked		
1995-2004						
TOTAL INDUSTRIES	3.1	-0.2	-0.4	3.5	100.0	3.5
Electrical machinery, post and communication	11.5	0.6	0.4	11.2	3.4	0.4
Manufacturing, excluding electrical	4.7	-1.7	-1.8	6.5	18.9	1.3
Other goods producing industries	0.9	-1.2	-1.3	2.2	29.6	0.7
Distribution services	4.0	0.4	0.0	4.0	19.3	0.8
Finance and business services	6.2	4.0	3.7	2.5	6.4	0.1
Personal and social services	1.5	1.3	0.8	0.7	5.5	0.0
Non-market services	2.1	0.2	0.1	1.9	16.9	0.3
Reallocation of labour effect						0.0

Source: EU KLEMS Database, March 2007, http://www.euklems.net.

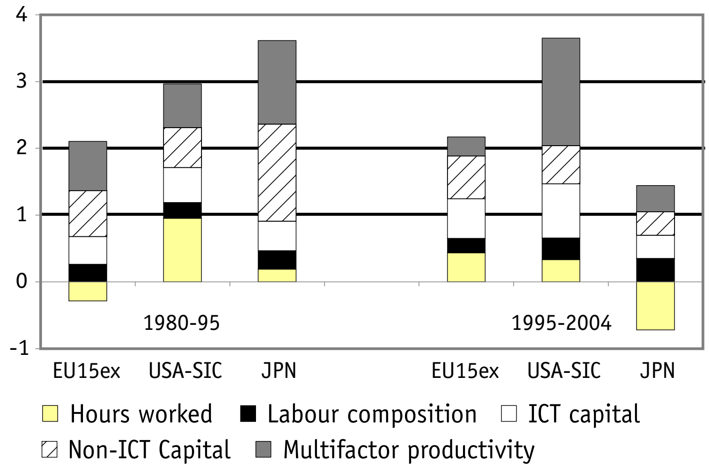
of the EU, i.e. Italy and Spain. The dismal productivity performance of the latter two countries impacts significantly on the average growth rate in the Union. However, whereas slow productivity growth in Spain was related to rapid improvement in labour input growth, the Italian economy experienced no compensating effect from an acceleration in employment growth. In general, the productivity growth rates from 1995-2005 were by far the highest for the new member states, reflecting the restructuring of the economies in Central and Eastern Europe. However, labour input growth in the new member states has generally been negative, in particular in manufacturing.

The underlying analysis of the industry contributions to labour productivity since 1995 shows that the manufacturing sector continues to contribute significantly to European growth, partly through high labour productivity growth

Chart 1

Contributions to Market Economy GDP Growth 1980-1995 vs. 1995-2004

(per cent, major regions)



Source: EU KLEMS Database, March 2007, http://www.euklems.net.

in the electrical machinery sector (which includes, for example, all the ICT production industries), and partly from the rest of the manufacturing sector (0.5 percentage points per year) (Table 2). Also growth in distribution services and in other goods producing industries contributed each 0.4 percentage points per year to post-1995 growth in the EU-25.

Nevertheless, compared to the United States, the striking differences in labour productivity growth originates from the much smaller contribution of market services, notably the distribution sector as well as finance and business services, which contributed 1.3 percentage points in the United States. EU aggregates hide considerable country variation in industries driving growth. For example, some European countries (Finland, Sweden and Ireland as well as Estonia, Hungary and Latvia) showed a major contribution from ICT production. Some have major contributions from other manufacturing, such as some fast-growing new EU-countries, Austria, Ireland and Sweden, while in other countries other goods production (which includes agriculture, mining, utilities and construction) is an important source of growth. Also differences in the productivity contribution of market services appear to be a major driver of divergence within Europe

The growth accounting analysis from the EU Growth and Productivity Accounts is the most innovative and hitherto unavailable component of the database. It concentrates on a sub-sample of eleven "old" EU countries and four new member states for which full labour and capital accounts could be constructed.[10] In Table 4, a decomposition of value added growth in the market economy of the old EU countries is given. GDP growth accelerated from 1.9 per cent to 2.2 per cent after 1995, completely due a strong improvement in the contribution of labour input, increasing from a zero contribution to a 0.7 percentage point contribution. About two thirds of this came from faster growth in total hours worked and one third from improved labour composition, as the overall skill level of the workforce has continued to increase significantly (Table 4).

The contribution of capital input to value added growth has not changed much at the aggregate level, but the distribution has shifted somewhat from non-ICT capital to ICT capital. However, compared to the United States the shift towards intensive use of ICT capital has generally not been as pronounced. Notably, when comparing the ratio of capital to labour contributions to growth in the EU, there are signs of a declining capital intensity in the EU. This development is in sharp contrast to the US trend in capital intensity since 1995 (Table 4).

10 The eleven "old" EU countries in the growth accounts analysis refer to Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom. The four new member states refer to Czech Republic, Hungary, Poland and Slovenia.

Table 4

Gross Value Added Growth and Contributions, 1980-1995 and 1995-2004

(annual average volume growth rates, in %)

A. European Union-15 (excluding Greece, Ireland, Luxembourg, Portugal and Sweden)

	VA	L	H	LC	K	KIT	KNIT	MFP
	(1)=(2)+(5)+(8)	(2)=(3)+(4)	(3)	(4)	(5)=(6)+(7)	(6)	(7)	(8)
1980-1995								
MARKET ECONOMY	1.9	0.0	-0.3	0.3	1.1	0.4	0.7	0.7
Electrical machinery, post and communication	3.9	-0.7	-0.8	0.2	1.6	0.9	0.8	2.9
Manufacturing, excluding electrical	1.2	-1.3	-1.5	0.3	0.8	0.2	0.6	1.7
Other goods producing industries	-0.2	-1.2	-1.4	0.2	0.9	0.2	0.7	0.2
Distribution services	2.6	0.4	0.0	0.3	0.8	0.3	0.5	1.4
Finance and business services	3.6	2.2	1.9	0.3	1.9	0.8	1.0	-0.7
Personal and social services	1.8	1.8	1.5	0.3	1.0	0.3	0.7	-1.1
1995-2004								
MARKET ECONOMY	2.2	0.7	0.4	0.2	1.2	0.6	0.6	0.3
Electrical machinery, post and communication	6.0	-0.4	-0.6	0.2	1.7	1.2	0.5	4.7
Manufacturing, excluding electrical	1.0	-0.3	-0.6	0.3	0.7	0.3	0.4	0.6
Other goods producing industries	1.2	0.0	-0.2	0.2	0.7	0.1	0.6	0.5
Distribution services	2.3	0.7	0.6	0.1	1.2	0.5	0.7	0.4
Finance and business services	3.5	2.1	1.9	0.3	2.3	1.3	1.0	-1.3
Personal and social services	1.7	1.5	1.4	0.1	0.9	0.3	0.7	-0.9

B. United States

	VA	L	H	LC	K	KIT	KNIT	MFP
	(1)=(2)+(5)+(8)	(2)=(3)+(4)	(3)	(4)	(5)=(6)+(7)	(6)	(7)	(8)
1980-1995								
MARKET ECONOMY	3.0	1.2	1.0	0.2	1.1	0.5	0.6	0.7
Electrical machinery, post and communication	6.6	0.1	-0.3	0.4	1.9	1.0	0.9	4.6
Manufacturing, excluding electrical	1.7	0.1	-0.2	0.3	0.6	0.3	0.3	0.9
Other goods producing industries	0.7	0.7	0.4	0.3	0.7	0.2	0.5	-0.7
Distribution services	3.9	1.3	1.2	0.2	1.2	0.6	0.6	1.3
Finance and business services	4.4	2.9	2.7	0.2	1.8	1.0	0.9	-0.3
Personal and social services	2.8	2.5	2.5	0.1	0.5	0.2	0.3	-0.2
1995-2004								
MARKET ECONOMY	3.7	0.7	0.3	0.3	1.4	0.8	0.6	1.6
Electrical machinery, post and communication	8.9	-0.3	-0.9	0.6	2.5	1.5	0.9	6.8
Manufacturing, excluding electrical	0.7	-1.1	-1.5	0.3	0.7	0.4	0.3	1.1
Other goods producing industries	1.6	1.0	0.9	0.1	0.9	0.2	0.6	-0.3
Distribution services	4.7	0.5	0.2	0.3	1.4	1.0	0.4	2.8
Finance and business services	4.9	2.0	1.6	0.4	2.0	1.2	0.7	0.9
Personal and social services	2.6	1.7	1.4	0.2	1.0	0.4	0.6	0.0

Source: EU KLEMS Database, March 2007, http://www.euklems.net

Notes:

VA= Gross value added growth
L= Contribution of labour input growth
H= Contribution of total hours worked
LC= Contribution of labour composition
K= Contribution of capital input growth
KIT= Contribution of ICT capital
KNIT= Contribution of non-ICT capital
MFP= Contribution of multifactor productivity growth

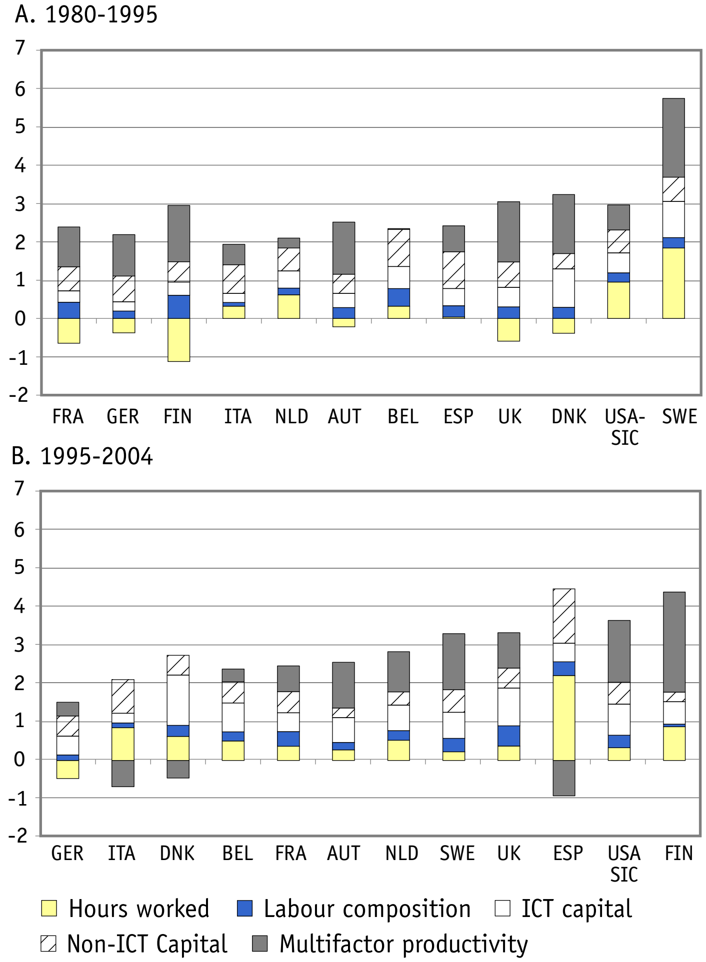
The factor contributing most to the diverging trends in Europe and the United States is the trend in multifactor productivity growth. While contributing 0.7 per cent per year to market economy GDP during 1980-1995 in both areas, the trend accelerated to 1.6 per cent in the United States, but declined to 0.3 per cent in the ten old EU after 1995 (Chart 1). This slowdown in MFP growth is recorded almost everywhere across the Union, with the exception of Finland and the Netherlands where it improved since 1995. In France, MFP growth in the market economy has remained stable at 0.7 per cent, but it slowed sharply in Germany and in the United Kingdom. In Italy and Spain, MFP growth was even negative reflecting the lack of technology and innovation spillovers and market rigidities, in particular in services industries (Chart 2).

When decomposing growth to both industry as well as the sources of growth, it appears that market services tell a major part of the divergent performance of European economies since 1995, both within Europe as well as relative to the United States. Table 4 shows causes of the slowing or stagnation of output growth in various market services. While the contribution of factor inputs to growth has generally stayed up, multifactor productivity growth in the market services stagnated or even turned negative in many European countries. The reasons for the slowdown in multifactor productivity growth in market services are an important avenue for further research.

Chart 2

Contributions to Market Economy GDP Growth

(per cent)



Source: EU KLEMS Database, March 2007, http://www.euklems.net.

Conclusion

The EU KLEMS Growth and Productivity Accounts offers a new set of data that provide researchers, policy makers, media and others with a rich source of information on the sources of growth by industry and by country in the European Union. Using national accounts and supplementary official statistics in combination with state-of-the-art growth accounting techniques, this database allows one to detect the key areas of growth and slowdown for individual countries, as well as convergence and divergence across economies. More precise measurement of the sources of growth at the industry level is important for the analysis of the causes of the growth slowdown. In particular, the breakdown of capital and labour inputs into asset types and labour categories (skill, gender and age) is an important step towards a more adequate assessment of the growth sources and less biased measures of multifactor productivity growth.

In December 2007, the second version of the EU KLEMS database will be published, containing data up to 2005. In addition, experimental estimates will be included, such as sectoral output measures which correct for intra-industry trade, a distinction between imported and domestically produced intermediates, measures of intangibles including human capital and R&D, and productivity level comparisons. Also, a further link with micro-level statistics will be sought.

The first release of the EU KLEMS database confirmed the view that European countries experienced a significant slowdown in productivity growth since 1995, which is shown to be widespread across countries and industries but with notable differences. For example, labour productivity growth in Spain and Italy declined seriously, while it slowed moderately in France and Germany. The productivity slowdown in the United Kingdom has been more limited, and in some smaller economies (Greece, Ireland, and the Netherlands) productivity growth even accelerated, at least in the market sector of those economies. Productivity growth in most new member states of the European Union has been much faster as these countries have been catching up to the productivity levels of "old" EU-15, but this has often been accompanied by a sharp contraction in employment.

The potential for a recovery in productivity growth will to a large extent depend on the EU's capability to transform the economy towards one that makes more productive use of its resources. Much will depend on the capacity of markets to facilitate the reallocation of resources to industries that show rapid productivity growth. However, it is difficult to predict which industries will be the most productive in the future, as technology and innovation trends are inherently difficult to forecast. For now, a productive use of a larger input from skilled employment and the exploitation of ICT investments in service industries appear the most successful policy avenues for a European productivity revival. The EU KLEMS database will be a useful policy tool to track the progress made.

References

EU KLEMS Database, March 2007, http://www.euklems.net

Inklaar, R., M. O'Mahony and M.P. Timmer (2005) "ICT and Europe's Productivity Performance; Industry-level Growth Account Comparisons with the United States," *Review of Income and Wealth*, Series 51, Number 4, pp. 505-36.

Jorgenson, D. W. and Z. Griliches (1967) "The Explanation of Productivity Change," *Review of Economic Studies*, Vol. 34, No. 3, pp. 249-83.

Jorgenson, D.W., F.M. Gollop and B.M. Fraumeni (1987) *Productivity and U.S. Economic Growth* (Cambridge, Mass.: Harvard University Press)..

Jorgenson, Dale W., Mun Ho and Kevin J. Stiroh. (2005) *Information Technology and the American Growth Resurgence* (Cambridge, Mass.: MIT Press).

O'Mahony, M. and B. van Ark, eds.(2003) *EU Productivity and Competitiveness: An Industry Perspective Can Europe Resume the Catching-up Process?* (Luxembourg: Office for Official Publications of the European Communities)..

Schreyer, P. (2002) "Computer Price Indices and International Growth and Productivity Comparisons," *Review of Income and Wealth*, Series 48, Number 1, pp. 15-31.

Timmer, Marcel P. and Bart van Ark (2005) "IT in the European Union: A driver of productivity divergence?" *Oxford Economic Papers*, Volume 57, Number 4, pp. 693-716.

Van Ark, Bart, Mary O'Mahony and Gerard Ypma, eds. (2007) "The EU KLEMS Productivity Report," Issue 1, University of Groningen and University of Birmingham, March.

Appendix Table 1
Variables in EU KLEMS database

Basic variables	
Values	
GO	Gross output at current basic prices (in millions of local currency)
II	Intermediate inputs at current purchasers' prices (in millions of local currency)
IIE	Intermediate energy inputs at current purchasers' prices (in millions of local currency)
IIM	Intermediate material inputs at current purchasers' prices (in millions of local currency)
IIS	Intermediate service inputs at current purchasers' prices (in millions of local currency)
VA	Gross value added at current basic prices (in millions of local currency)
COMP	Compensation of employees (in millions of local currency)
GOS	Gross operating surplus (in millions of local currency)
TXSP	Taxes minus subsidies on production (in millions of local currency)
EMP	Number of persons engaged (thousands)
EMPE	Number of employees (thousands)
H_EMP	Total hours worked by persons engaged (millions)
H_EMPE	Total hours worked by employees (millions)
Prices	
GO_P	Gross output, price indices, 1995 = 100
II_P	Intermediate inputs, price indices, 1995 = 100
VA_P	Gross value added, price indices, 1995 = 100
Volumes	
GO_QI	Gross output, volume indices, 1995 = 100
II_QI	Intermediate inputs, volume indices, 1995 = 100
IIE_QI	Intermediate energy inputs, volume indices, 1995 = 100
IIM_QI	Intermediate material inputs, volume indices, 1995 = 100
IIS_QI	Intermediate service inputs, volume indices, 1995 = 100
VA_QI	Gross value added, volume indices, 1995 = 100
LP_I	Gross value added per hour worked, volume indices, 1995=100
Growth accounting variables	
LAB	Labour compensation (in millions of local currency)
CAP	Capital compensation (in millions of local currency)
LAB_QI	Labour services, volume indices, 1995 = 100
CAP_QI	Capital services, volume indices, 1995 = 100
VA_Q	Growth rate of value added volume (% per year)
VAConL	Contribution of labour services to value added growth (percentage points)
VAConH	Contribution of hours worked to value added growth (percentage points)
VAConLC	Contribution of labour composition change to value added growth (percentage points)
VAConKIT	Contribution of ICT capital services to output growth (percentage points)
VAConKNIT	Contribution of non-ICT capital services to output growth (percentage points)
VAConTFP	Contribution of TFP to value added growth (percentage points)
TFPva_I	TFP (value added based) growth, 1995=100
GO_Q	Growth rate of gross output volume (% per year)
GOConII	Contribution of intermediate inputs to output growth (percentage points)
GOConIIM	Contribution of intermediate energy inputs to output growth (percentage points)
GOConIIE	Contribution of intermediate material inputs to output growth (percentage points)
GOConIIS	Contribution of intermediate services inputs to output growth (percentage points)
GOConL	Contribution of labour services to output growth (percentage points)
GOConK	Contribution of capital services to output growth (percentage points)
GOConTFP	Contribution of TFP to output growth (percentage points)
TFPgo_I	TFP (gross output based) growth, 1995=100

Additional variables	
CAPIT	ICT capital compensation (share in total capital compensation)
CAPNIT	Non-ICT capital compensation (share in total capital compensation)
CAPIT_QI	ICT capital services, volume indices, 1995 = 100
CAPNIT_QI	Non-ICT capital services, volume indices, 1995 = 100
CAPIT_QPH	ICT capital services per hour worked, 1995 reference
CAPNIT_QPH	Non-ICT capital services per hour worked, 1995 reference
LABHS	High-skilled labour compensation (share in total labour compensation)
LABMS	Medium-skilled labour compensation (share in total labour compensation)
LABLS	Low-skilled labour compensation (share in total labour compensation)
LAB_QPH	Labour services per hour worked, 1995 reference
H_HS	Hours worked by high-skilled persons engaged (share in total hours)
H_MS	Hours worked by medium-skilled persons engaged (share in total hours)
H_LS	Hours worked by low-skilled persons engaged (share in total hours)
H_M	Hours worked by male persons engaged (share in total hours)
H_F	Hours worked by female persons engaged (share in total hours)
H_29	Hours worked by persons engaged aged 15-29 (share in total hours)
H_49	Hours worked by persons engaged aged 30-49 (share in total hours)
H_50+	Hours worked by persons engaged aged 50 and over (share in total hours)

Source: EU KLEMS Database, March 2007, http://www.euklems.net.

Appendix Table 2
List of Industries for Growth Accounting Variables

Description	Code
TOTAL INDUSTRIES	TOT
MARKET ECONOMY	MARKT
ELECTRICAL MACHINERY, POST AND COMMUNICATION SERVICES	ELECOM
Electrical and optical equipment	30t33
Post and telecommunications	64
GOODS PRODUCING, EXCLUDING ELECTRICAL MACHINERY	GOODS
TOTAL MANUFACTURING, EXCLUDING ELECTRICAL	MexElec
Consumer manufacturing	Mcons
Food products, beverages and tobacco	15t16
Textiles, textile products, leather and footwear	17t19
Manufacturing nec; recycling	36t37
Intermediate manufacturing	Minter
Wood and products of wood and cork	20
Pulp, paper, paper products, printing and publishing	21t22
Coke, refined petroleum products and nuclear fuel	23
Chemicals and chemical products	24
Rubber and plastics products	25
Other non-metallic mineral products	26
Basic metals and fabricated metal products	27t28
Investment goods, excluding hightech	Minves
Machinery, nec	29
Transport equipment	34t35
OTHER GOODS PRODUCTION	OtherG
Mining and quarrying	C
Electricity, gas and water supply	E
Construction	F
Agriculture, hunting, forestry and fishing	AtB
MARKET SERVICES, EXCLUDING POST AND TELECOMMUNICATIONS	MSERV
DISTRIBUTION	DISTR
Trade	50t52
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	50
Wholesale trade and commission trade, except of motor vehicles and motorcycles	51
Retail trade, except of motor vehicles and motorcycles; repair of household goods	52
Transport and storage	60t63
FINANCE AND BUSINESS, EXCEPT REAL ESTATE	FINBU
Financial intermediation	J
Renting of machinery and equipment and other business activities	71t74
PERSONAL SERVICES	PERS
Hotels and restaurants	H
Other community, social and personal services	O
Private households with employed persons	P
NON-MARKET SERVICES	NONMAR
Public admin, education and health	LtN
Public admin and defence; compulsory social security	L
Education	M
Health and social work	N
Real estate activities	70

Source: EU KLEMS Database, March 2007, http://www.euklems.net.