Editor's Overview

THE 23RD ISSUE OF THE *International Productivity Monitor* includes five articles on: business innovation strategies and policies to stimulate innovation in Canada; new direct measures of the use of computer technologies in Canada and the United States and implications for Canadian productivity growth; the reasons behind the large divergence between labour productivity and real median wage growth in the United States over the 1973-2011 period; the relationship between educational attainment, employment rates and productivity in OECD countries; and the treatment in the national accounts of measures of volume output for education and health services.

It is widely recognized that Canada's lagging productivity performance is closely related to weak business innovation. In the lead article **Marcel Côté** and **Roger Miller** from the economic consulting firm Secor put forward a new framework for understanding innovation that they call the six games of innovation. Innovative activity is broken down into six types or games based on the maturity of the market (emerging or mature) and the product architecture (stand alone, open system, and closed system). This framework provides much insight into how firms make strategic decisions related to their innovative activity.

According to Côté and Miller, the games of innovation framework throws into question the effectiveness of the current approach to innovation policy in this country. They point out that the two key features of Canada's innovation policy are generous R&D tax credits for business and substantial support for university research. But these tax credits appear to have little effect on business innovation, other than reducing the cost. While financial support for university research is positive from the perspective of the advancement of knowledge and Canada's international reputation for research, the weak linkages between this research and the private sector means that it has limited direct relevance for business innovation. Côté and Miller argue that industry and project-specific support for innovation and regionally focused innovation assistance would be more effective levers to improve the country's innovation performance.

Technological progress in the computer field is a key driver of productivity growth. The widening gap between the level of labour productivity in Canada and the United States suggests that Canada is trailing its southern neighbour in the implementation of productivity-enhancing computer technologies. But until now direct evidence of the lag in Canada's adoption of computer technologies relative to the United States has been lacking. In the second article, **Michelle Alexopoulos** and **Jon Cohen** from the University of Toronto make an important contribution to the productivity debate by presenting new direct measures of the penetration or presence of computer technologies in the two countries.

The authors have put together estimates of the number of titles of computer books held in Canadian and U.S. libraries over the 1950-2005 period. They show that beginning in the early 1970s a gap in the absolute number of computer titles emerged between the two countries. Given the strong causal relationship they find between these indicators and total factor productivity growth, they conclude that the more limited development and use of computers technologies in Canada has played a key role is the widening of the Canada-U.S. productivity gap since the early 1980s.

Productivity growth makes possible higher levels of living standards for the average worker as the increased output per hour worked can be used to pay higher wages. But this relationship between labour productivity growth and real median wages has broken down in the United States. While output per hour advanced 80 per cent between 1973 and 2011, real median wages were virtually stagnant. In the third article, **Lawrence Mishel** from the Economic Policy Institute and **Kar-Fai Gee** from the Centre for the Study of Living Standards develop a framework to decompose the relationship between productivity and median wages into four mediating factors and provide estimates of the importance of these factors.

They calculate that labour productivity growth outstripped real median wage growth in the United States by 1.46 percentage points per year (1.56 per cent versus 0.10 per cent) between 1973 and 2011. The most important source of this divergence was growing wage inequality, accounting for 41 per cent of the difference. This was followed by deteriorating terms of trade for labour–that is, faster growth in the consumption price index than the GDP deflator–responsible for 30 per cent of the difference. The falling share of labour income and rising worker benefits accounted for the remaining 28 per cent. The authors identify globalization and the declining bargaining power of workers as driving forces behind this alarming and disturbing disconnect between productivity and wages.

Productivity growth is influenced by both the educational attainment of the workforce and employment rates. In the fourth article **Renaud Bourlès** from Ecole Centrale Marseille and GREQAM-IDEP, **Gilbert Cette** from the Banque de France and Université de la Méditerranée and **Anastasia Cozarenco** from Université de la Méditerranée and GREQAM attempt to disentangle the effect of employment structure and educational attainment on productivity in OECD countries using econometric techniques. They find that a one percentage point increase in the employment rate for all three educational groups (less than secondary, secondary, and higher) reduces labour productivity by around 0.6 per cent, as the persons entering employment from non-employment tend to be less productive than those already employed.

In a simulation exercise, the authors identify significant potential gains for OECD countries in terms of productivity and GDP from moving to the education attainment structure of the country with the highest level of educational attainment (Canada) and to the employment rate structure of the country (Denmark) with the highest total employment rate.

The absence of marketed output for most education and health services has meant that volume output of these industries could not be measured independently on inputs. This shortcoming in the estimation of volume output in the non-market sector has long been recognized and is now increasingly the focus of attention, given the need to have accurate measures of overall economic performance and to improve productivity in education and health services. In the fifth and final article of the issue **Aled ab Iorwerth** from Finance Canada examines the recent OECD publication *Towards Measuring the Volume Output of Education and Health Services: A Handbook* which provides the state of the art on the measurement of education and health services.

The author welcomes this OECD initiative to identify and develop best practices for measuring the volume output of education and health services. He recommends that the focus of attention be on the estimation of the value of production of these industries, not the well-being or social valuation arising from these services given the sensitivity of these valuations to different assumptions.

Stimulating Innovation: Is Canada Pursuing the Right Policies?

Marcel Côté and Roger Miller[1]
Secor

ABSTRACT

Based on a global survey of over 800 innovative firms, a new framework has been developed by the authors to understand innovation. Using the perspective of the innovators to explain the diversity of the strategies behind business innovation, they identified six broad patterns called games of innovation around which innovations are structured. The article points out that this framework raises significant issues about the effectiveness of current Canadian innovation policies. In light of the productivity challenges that Canada faces, which appear to be largely related to innovation, the framework also provides useful insights into future directions for public policies.

RÉSUMÉ

Sur la base d'une enquête auprès de plus de 800 entreprises innovatrices de partout dans le monde, un nouveau cadre conceptuel a été développé par les auteurs pour mieux saisir le phénomène de l'innovation. Empruntant la perspective des innovateurs, ce cadre conceptuel explique la diversité des stratégies d'innovation par la présence de six modèles ou"jeux d'innovation". L'article indique que ce cadre conceptuel soulève de nombreuses questions quant à l'efficacité des stratégies publiques d'innovation poursuivies au Canada. Compte tenus des défis de productivité du Canada et du rôle que joue l'innovation à cet égard, les "jeux d'innovation" fournissent des pistes intéressantes quant à l'orientation de ces politiques.

CANADA HAS A PRODUCTIVITY PROBLEM. The dramatic widening between Canadian and U.S. labour productivity levels is one of the most important challenges facing economists in this country. The gap, now between 25 per cent and 30 per cent in the business sector, has been increasing since 1984, when Canadian output per hour reached a historic peak of 92 per cent of the U.S. productivity level. In 2010, Canada ranked 15th on the same indicator among the 30 OECD countries, and was in the third quartile in terms of productivity growth rates.

The causes behind this poor performance have been debated for several decades. No economic issue has garnered more attention than trying to explain why Canada lags the United States in terms of productivity growth. Under-investment in machinery and equipment, espe-

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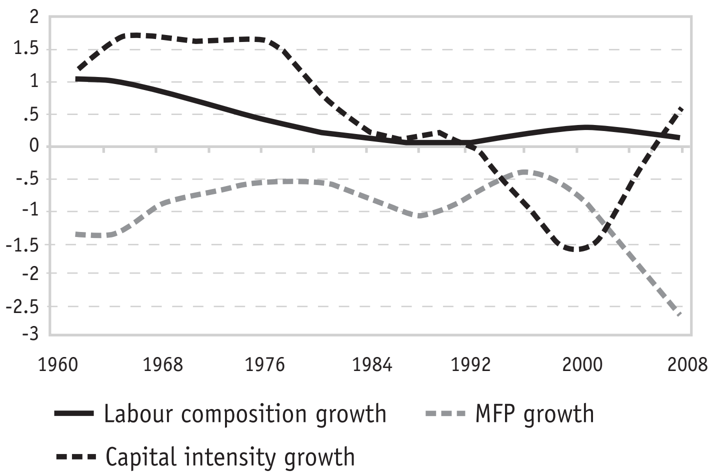
Chart 1
Canada-United States Difference in Growth of Multifactor Productivity (MFP), Capital Intensity and Labour Composition, Business Sector, 1962-2008
(percentage points)



Sources: Statistics Canada; Bureau of Economic Analysis.

cially in information and communication technologies (ICTs) is often mentioned. The underdevelopment of our financial sector compared to that of the United States has been also pointed to, as well as lower productivity from self-employed business owners (Baldwin and Chowhan, 2003).

A study by Baldwin and Gu (2009) compared Canadian and U.S. labour productivity growth in the business sector over a 47 year period ending in 2008 and concluded that neither labour quality nor capital intensity can explain the widening gap. As Chart 1 shows, Canada has consistently outperformed the United States in terms of the contribution of labour quality to productivity increase. On capital intensity, Canada's performance is mixed. But except for the 1992 to 2006 period, when the Canadian dollar was well below parity, capital intensity has contributed to narrowing the gap.

As Chart 1 clearly shows, the culprit is the much maligned and poorly understood multifactor productivity, considered by many a good proxy for technological progress. Canada has scored consistently in negative territory relative to the United States on this indicator. There is a strong consensus that innovation, that is, a more effective use of labour and capital, is the prime factor underlying multifactor productivity and technological progress, or at least that component of technological progress not embodied in capital goods.

For over 50 years, our federal and provincial governments have been pursuing policies aimed at stimulating innovation. We have the National Research Council, R&D tax credits, networks of excellence, technology transfer centres, the CANDU reactor, the Challenger jet, MaRS and so on. But these efforts, whose costs now total between $10 and $20 billion per year depending on the yardstick, have yet to significantly move the productivity needle.

On behalf of the federal government, the Council of Canadian Academies (2009) set up a panel in 2007 to investigate why business sector productivity growth in Canada was lagging that of the United States.[2] The report concluded that the culprit, if there was to be one, was Canadian business itself, which chose deliberately not to pursue business strategies that rely on innovation, as there were easier ways of making profits. That begs the question as to whether current government policies on innovation were effective at influencing business behaviour.

That led to a second panel, known as the Jenkins panel, which reviewed federal support programs for R&D and reported in the fall of 2011 (Government of Canada, 2011). But other than "deconstructing" the National Research Council by allocating some of its institutes to universities and pushing the others closer to

2 For a synthesis of the report see Nicholson (2009) as well as other articles from the symposium on the report in the Spring 2009 issue of the *International Productivity Monitor*.

businesses, the panel's recommendations do not call for fundamental changes to the current public policy framework. They focus mostly on fine tuning current programs, and in particular, the SR&ED tax credits. The 2012 federal budget is likely to implement most of their recommendations, albeit some with minor changes.

Will the Jenkins panel recommendations make a difference and spur more innovation in Canada? This article expresses significant reservations: Canada's public policies on innovation need a much more fundamental review if they are to impact innovation in a significant way.

What We Know and What We Do Not Know about Innovation

As defined in the Oslo manual (OECD, 2005), an innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace or external relations. It covers everything from the introduction of insulin to that of Gillette's five-blade razor. It also includes improvements in business processes (e.g. lean production), management methods (e.g. Kaizen) and business models (e.g. Freemium pricing).

Although innovation is still much of a black box, there are several aspects on which there is general acceptance. In summary, an innovation is a product, service or a way of doing something which is superior to what existed, and which is adopted. It is different from an invention as it requires acceptance by the market and not only recognition by peers. It is also different from advancements in knowledge, as it must become embedded in a system of production and distribution. There are various types of innovation. Schumpeter popularized the concept of radical innovations that usher major technological waves that can profoundly change industrial structures, such as the automobile. The concept of disruptive innovation developed by Christensen (1997) is a related concept, capturing innovations that change the fundamental technologies of an industry. More common are incremental innovations which are improvements in products and processes that create competitive advantages without disrupting an industry.

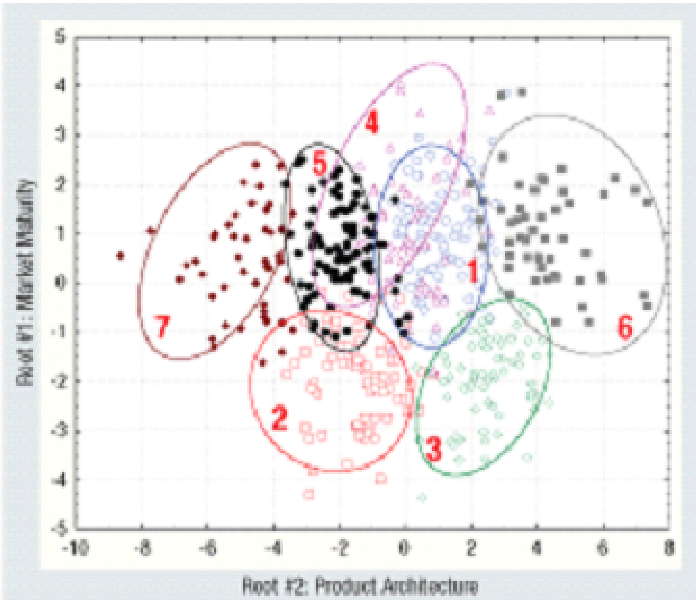
But innovation is not the purview of only economists. Management science has taken a great interest in innovation and has greatly advanced our understanding. Among findings of interest, successful innovation typically requires more marketing than R&D. Stimulating innovation in organizations is a cultural challenge. The role of patents has generated significant research in business and legal circles. But there is still much to understand about the management of innovation. A search on Amazon.com using innovation as a key word reveals nearly 50 thousand entries. Although this number likely includes some double counting, it nevertheless underscores the fact that innovation attracts substantial interest.

In 2000, the two of us, bringing together field experience in business and scholarly credentials, embarked upon a quest to better understand innovation. The result of that partnership is a book, *Innovation Reinvented: Six Games That Drive Growth*, which is being published in the spring of 2012 by the University of Toronto Press (Miller and Côté, 2012). The book represents an analysis of innovation from the perspective of the innovators, an analysis that led us to challenge many of the current public policies aimed at stimulating innovation. This article provides a synthesis of the book and presents our case.

The MINE Project

In 2000, Roger Miller launched a large scale study of innovation known as the MINE project (Managing Innovation in the New Economy)

Chart 2
The Cluster Analysis Results



and invited Marcel Côté to sit on the Steering Committee. MINE attempted to document the diversity of innovation strategies developed in response to the changes and opportunities generated by the spread of information and communication technologies (ICT). Over 800 business organizations from all over the world responded to a detailed survey on the why, what and how of their innovation strategies. The survey was supplemented by 50 case studies of well-recognized innovative firms, from General Electric to Michelin, which were done in parallel and all of which involved interviews with at least three senior executives associated with the respondent's innovation strategies.

Making sense of the results was challenging. Extensive statistical analysis was done on the survey data. Seven clusters, shown in Chart 2, were finally identified by us. Six of them were relatively well defined by two canonical roots, which corresponded to two sets of characteristics of the business environment of the respondent firms, namely the maturity of the market and the architecture of the product they were selling. The seventh cluster grouped research agencies and consulting organizations that helped businesses innovate. They were deemed to be in the ecosystem of the innovators and were not considered in our analysis.

Identifying these two dimensions, and their ability to characterize the universe of businesses engaged in innovation was the major contribution of the quantitative analysis to our research projects. What we gradually realized was that using the innovator perspective provided a fresh look at innovation. Crossing the two dimensions yields six fairly homogeneous patterns, which we called games of innovation. We then used the fifty case studies to enrich our understanding of each game.

The Innovation Game Framework

The diversity of the patterns of innovation, from insulin to the five-blade razor, has always puzzled researchers. The six games defined by crossing the two dimensions addressed this issue: not only is a game associated with a particular business context, but it also calls for a specific set of innovation strategies. In other words, broken down into six games, the diversity of the innovation experience is much better understood.

Maturity of a Market: Two States – Emerging and Mature

In an emerging market, from the time an invention is first commercialized successfully, becoming an innovation, to the time the product (or service) has reached most of its potential customers, a market is characterized by a continuous flow of innovations, some big, some small, as the product is refined and improved upon. The market is characterized by rapid growth, and initially supports the entry of numerous emulators.

Table 1
The Six Games of Innovation

		Product (and Service) Architecture		
		Stand alone	**Open system**	**Closed system**
Market Maturity	**Emerging**	**Eureka!** Nespresso	**Battle of architecture** Smart Phone	**System Breakthrough** Early ERPs
	Mature	**New and Improved** Tide Detergent	**Mass Customization** Wal Mart	**Pushing the Envelope** TGV

After 10 to 15 years, when the market approaches maturity, a rapid consolidation is generally seen, as a few winners emerge. (In Chart 2, clusters 1, 2 and 3 group the organizations active in emerging markets and clusters 4, 5, and 6 mature markets.)

In a mature market, starting some twenty years after the market has emerged, the customer base becomes saturated. Innovation is much more paced, as competitors try to differentiate their products and lower their costs, fighting for the same customers. Growth has tapered off to the general rate of the economy.

Product Architecture: Three States – Stand-alone, Platform-based Open System, Closed System

Many products are dependent on other products to deliver their benefits. An airplane engine is part of a closed system, integrated into a plane. A Facebook application requires the Facebook platform to deliver its benefits, but the platform is open and can accommodate a wide range of applications. A stand-alone product such as the classic mouse trap is not constrained in its innovation strategies. Architecture is a major determinant of innovation strategies. (In Chart 2, clusters 1 and 4 were associated with stand-alone architectures, clusters 2 and 5 with closed systems and clusters 3 and 6 with open systems.)

The combination of these two dimensions gives rise to six games, as Table 1 illustrates. At any given time, a market is characterized by one game, which defines how market participants will approach innovation. Each game also calls for specific competencies.

The evolution of the smartphone market over the years can illustrate the concept of a game, in that instance a battle of architecture. The smartphones game started in 1997, when Research in Motion (RIM) introduced a pager that transmitted e-mail instead of phone numbers. Emulators sprang up rapidly, but flush with cash from its 1998 IPO, RIM took a strong early lead. The Blackberry with the scrolling wheel on the side came out in 1999. In 2002, RIM managed to add the telephone function, a breakthrough that allowed texting and which progressively brought most of the mobile telephone manufacturers in the market as competitors, and gave rise to the development of a consumer segment in what had been mostly a business market. Many small improvements were progressively added as a continuous flow of new models were launched. Then, in 2007, Apple launched the iPhone, adding design and much improved Web functionalities. The entry of Apple accelerated the wave of small innovations as competitors reacted and adjusted. In 2009, Google launched its Android platform; determined to capture a big share of the market, it chose to license it at no cost. Within three years, it had captured 50 per cent of the North American market, making it a highly profitable product for Google as it reaps advertising revenue.

Market growth is still rapid, above 10 per cent per year in North America, and leaping by up to 50 per cent a year in developing countries. RIM is still there, no longer the market leader, but with a strong franchise in the business segment. But growth will taper off in five or six years, as market penetration crosses the 50 per cent mark and most people who want a smart phone will have one. By that time, the global market will be dominated by a handful of players. The design will also have stabilized, and innovation will change allure.

Here is a quick review of the six games.

Eureka!: Recognizing the commercial potential of an invention, the genesis of an Eureka! game, emulators flock into the emerging market, improving the product rapidly through their individual contributions, as the market grows rapidly. The single cup coffee machine market is typical of an ongoing Eureka! race that has still not hit maturity. Attracting first-time customers is the name of the game, putting a strong emphasis on marketing and product management. Agility and the ability to manage rapid growth are essential. As growth eventually tapers off, distribution becomes critical, crowding out smaller players, and the market consolidates around a limited number of competitors.

New and Improved: As a classic product in that game, we use Tide's popular slogan to name the game, which is the most common of all the games of innovation. In this game, the innovation is almost always incremental and can bear on the product, on the processes, and from time to time, on the business model. The game dominates industrial markets (from paper to iron ore), consumer markets and in many services. To play in the game, an organization has to choose innovation as a strategic thrust, which many don't do. Innovative companies in this game are characterized by a strong change-oriented culture and by the integration of the pursuit of continuous improvement in their business processes.

Battle of Architecture: Characterized by multi-sided markets, this game is "orchestrated" by emerging platforms that form coalitions of developers and distributors, and which compete with each other to attract customers with an open set of benefits. The smartphone and social media markets are typical of such a battle. Network effects ("the more, the better") are critical in this game. Aggressive marketing and pricing policies are generally required early in battles of architecture to rapidly reach the threshold of customers that will kick in network effects. As a consequence, the best product does not always win, as the classic VHS-Beta battle taught us three decades ago. Also critical in this game is coalition management, an art in itself in these markets, as Steve Jobs, a master in that regard, has shown. Battles of architecture are characterized by rapid consolidation, very early in the game, as also-ran platforms are rapidly forgotten. This game is increasingly frequent in the internet world, where platforms abound.

Mass Customization: Mature platforms engaged in mass customization are found mostly in mass retailing and in complex products such as the automobile. The orchestrator of the platform offers a wide selection of benefits to its customers, as demand is increasingly segmented (customized). Innovation bears on the underlying systems, which have to be continually improved, and on the modules (products, components, etc.) that are attached to the platforms, and which must be continually renewed. Best practices bears on managing the evolution of the basket of benefits while keeping the integrity of the system's brand (from Walmart to Toyota) that encapsulates the promise to the customers. Managing the network of suppliers, and keeping them innovative, is also a critical skill.

System Breakthrough: This game starts with a deep-pocket customer who faces a major prob-

Table 2
Contribution of Innovation Games to Economic Growth

	Share of GDP	Contribution to growth through innovation			
		Stand alone	Open system	Closed system	Total
Emerging market	10%	**Eureka!** 15%	**Battle of architecture** 15%	**System Breakthrough** 5%	35%
Mature markets	90%	**New and Improved** 30%	**Mass Customization** 20%	**Pushing the Envelope** 15%	65%
Total	100%	45%	35%	20%	100%

lem or bottleneck, and who partners with an organization to develop the solution. Such a call is what gave birth to great companies such as SAP and Microsoft, the first one "inventing" the ERP software, the other one developing one of the first operating systems for personal computers. Success usually rests on strong collaboration between the determined customer (ICI and IBM in the two examples above) and the solutions provider, as budget overruns and extensive delays are likely to strain the partnership. Another important factor for these games to develop is the ability of the solution provider to commercialize the breakthrough to other customers, competing with smart emulators that step in to offer similar solutions.

Pushing the Envelope (PTE). The counterpart of system breakthrough in mature markets, PTE games are fuelled either by customers' ambition and ego or by their strategic decision to develop a sustained competitive advantage. The customers call upon "experts" to help them develop innovative projects that redefine the state of the art. Building a new generation of TGV, the tallest building in the world, the most advanced airport, or a large infrastructure project that pushes the limits of the state of the art, are typical PTE manifestations. So are the large innovative information-based business systems, often coupled with major capital investments, that allow organizations to leap ahead of their competitors.

No game is eternal. Game transitions, brought on by either market maturity or by fundamental technological waves, are often encountered, destabilizing the existing order. Incumbents are often short-changed during these transitions as they are run by people that do not have the right skills and competencies to succeed in these new games. The traditional telecom market was destabilized in the 1990s as the internet arrived and mobile communication spread. The telcos offer a good example of the challenges involved. In the 1980s, they were among the largest companies in the world, and many of them sought to diversify out of their basic mature businesses. Then, right on their own networks, the trillion dollar internet industry developed. Despite their huge cash flows and access to the best consultants and investment bankers in the world, not one of the telcos was able to enter the internet business in any significant way. The internet space is now dominated by companies started since then while telcos are increasingly confined to the transportation of kilobits, a commodity business if ever there was one.

Growth Accounting

The footprint of the emerging markets, where new products grow rapidly, is much smaller than commonly believed, as Table 2 shows. The internet economy, including the e-commerce activities at their retail income value, represents about 4 per cent of GDP (Pélissié du Raussas, 2011). The ICT-production activities, which partly overlap the internet economy, also represent around 4 per cent of GDP (Donahoe *et al.*, 2010 and BEA, 2011). Life science as a sector is around 1 per cent of GDP. We estimate that emerging markets, defined as those activities that are growing at three times or more the rate of the overall economy (and on the average, at five times), are contributing at most 10 per cent of GDP. The rest is made up of mature markets.

Our estimates of the contribution of the industries engaged in each game to the overall contribution of innovation to technological progress suggest that emerging markets represent only one third of it, the rest coming from mature markets. We should also point out that the stand alone games are dominant in sectors that are estimated to represent about 45 per cent of the value added in the economy. However, as ICT spreads, we should expect open system games, now dominant in about a third of the economy, to increase in importance.

Identifying Levers for Public Policy

The quest to understand why and how businesses pursue innovation led us to ask how public policies can affect their behaviour. Which policies can best lever innovation in business? Before addressing this question, here are some of the lessons for public policy that stem from the games-of-innovation framework

- Innovation rests first and above all with a decision by a business to pursue an innovation strategy, as the Council of Canadian Academies panel on business productivity had also concluded in 2009. Pursuing innovation is inescapable in emerging markets, where a business that does not innovate is bound to fail rapidly. But in mature markets, it is another story. A majority of businesses and indeed, of all organizations, as we can include governmental and municipal, university, school, and health (MUSH) organizations, do not incorporate innovation into their strategies, at least beyond lip service.[3] A starting point for any innovation policy is to find the proper levers that will induce businesses in mature markets to incorporate innovation in their strategies.
- In mature markets, the second most important factor for a business to innovate, beyond a strategic commitment to innovation, is a corporate culture whose dominant trait values continuous improvement in products and process and supports organizational change. Innovative organizations take innovation seriously. It shows in their culture and in their acceptance of change, generally structured by a customer orientation focus. In emerging markets, the most important competencies to succeed are marketing and product management, followed by agility and managerial ability to cope with rapid growth. How public policies affect such variables is an important issue.
- Paradoxically, R&D is not on the list of the principal drivers of innovation. Although it is associated with a large proportion of innovations, it is seldom a critical factor. In both emerging and mature markets, the vast majority (over 95 per cent) of innovations involve improvements to what exists in the market or in the production process. It may require some R&D, but the most critical factors in the success of an incremental innovation is the decision of what to do and how to market it if it is a product, or how to implement it if it is a process improvement.

3 Booz & Co. surveys annually the thousand businesses that do the most R&D globally. Even among these businesses, only half make innovation a meaningful element of their business strategy. We assume that this proportion is even less for other organizations. See Jaruzelski, Loehr, John and Holman (2006).

The R&D component is generally a mundane task in this process. This explains why R&D intensity is poorly correlated with innovation performance.[4]

- A big exception to the previous statement is in closed system games (System Breakthrough and PET), where ambitious customers hire experts and challenge them to develop breakthrough solutions or push the envelope beyond current solutions. R&D is often at the core of the projects undertaken in these games, and they can be made more attractive through risk-sharing policies. That approach is one of the mainstays of the DARPA (Defense Advanced Research Projects Agency) strategy in the United States. The approach is increasingly popular with governments in most industrial countries as part of their advanced technology development strategies, in areas such as space, transportation material, energy production and green energy.
- The original inventions (or breakthrough innovations) that give rise to an emerging market, such as the first smartphone, the first social network, the first personal watercraft or a new chemical process, are few compared to the thousands and thousands of innovations that follow in the wake of the market-creating innovation. Furthermore, the innovator/inventor behind most breakthrough innovations does not generally survive more than a few years in the industry, pushed aside by smarter and more competitive emulators that rapidly improve the original ideas. From an industrial policy point of view, supporting a good emulator is much more productive that supporting a "breakthrough innovator". The pharmaceutical sector is an exception to this general rule, as most innovations in this sector are subject to stringent regulation that not only slow down the pace of development of any innovative product and of its emerging market, but also limit the entry of emulators, which just compounds the inertial impact of regulation.
- Innovations result from the integration (or grafting) of new ideas onto existing products and processes. These ideas can come from a wide range of sources: customers, employees, suppliers, competitors, internal R&D and increasingly, from "out there". Open innovation is the biggest trend in the realm of innovation now, being embraced by the most innovative companies such as Procter and Gamble and General Electric. On the other hand, universities are seldom mentioned as a source of ideas, except in closed system innovation projects where universities based experts are asked to collaborate on.
- The major contribution of universities to innovation is not their research, but the graduate students that are hired by innovating companies and who can absorb leading edge knowledge and integrate it in their processes and products. University research is important, but its main contribution is to the advancement of knowledge, which is diffused in the global commons of ideas. Some of it may come back in some form or other to businesses, as ideas and concepts that are integrated in improved products and processes, and in relatively few instances, ideas and concepts that result in a new product or service that creates a new market and start a new game. On the other hand, well trained and talented individuals graduating from a local university who decide to stay in the region, and who can identify good ideas in

4 Analysing their data base of global technology intensive businesses, Booz & Co. found that R&D intensity was not correlated with indicators of innovation performance such as 5-year sales growth, profitability, profit growth and return on capital. See Jaruzelski *et al.* (2006).

the global commons, are highly sought by fast growing businesses.

- Intellectual property (IP) is important in the innovation process. But patents, a key provider of IP, do not play the critical role that is commonly assumed, as they are awarded too late in the process, when the critical commercial battles have been fought. Patents can generate significant revenues. But with the exception of some highly regulated sectors such as life sciences, they provide little protection to an innovator when *it matters*, that is in the months following the market introduction of the innovative product or the installation of a new process. This is a period when emulators swarm around the innovator and his innovation, and not only copy it, but improve the features of the product or process. Brands, copyrights and good old secrecy are much more useful during these critical moments when a product or a process becomes public. In the smartphone and tablet markets for instances, new products are reverse-engineered within a few days of their launch. An innovator must ensure that these innovative products are commercially successful in their most important first few years of production and are protected from copycats and their cheaper prices. Copyrighted brands and to a lesser extent, jealously guarded production secrets, give that protection. Recent patent skirmishes between Apple and Google and its surrogates had little to do with innovation and reflected the hard-ball competitive tactics between two global platforms.[5]

The "games of innovation" framework facilitates the identification of what matters to foster innovations. What it does first and foremost is to place innovations in their real world context, which is usually within a continuous stream of improvements in products and processes, with an occasional breakthrough that gives rise to a new market or disrupt an existing one. An effective set of public policies aimed at stimulating innovation should target the continuous stream of improvements.

Current Public Policies

Many of Canada's current public policies to stimulate innovation do not fare well under the games-of-innovation framework. This section reviews the most important of these policies, grouped into four categories that integrate both federal and provincial initiatives.

Tax Support for Industrial R&D

Costing about $5 billion per year in Canada, or 1/3 of 1 per cent of GDP, the highest among the OECD countries, tax credits reduce the cost of R&D, one of the factors, although rarely the most important, behind most innovations. For instance, in emerging markets, marketing and distribution costs of "new" products are generally more important than R&D spending. Although reducing the cost of one factor reduces the overall cost of the innovation, to what extent is R&D the best cost lever in emerging markets? A more basic question is whether cost reduction is a good lever in an emerging market, as competition demands that a firm innovate or perish. R&D costs are usually not central to the strategic decisions that shape what and when the firm will launch an improved product, compared to time to market, marketing and distribution issues, and competitive activities. The same questions can be asked in mature markets, where R&D tax credits are specially prized by R&D intensive firms, which often have become hooked on these injections of cheap capital. But are they better innovators in return? Or does the low cost of R&D bring them to support marginal projects that are R&D and tax credit intensive?

5 Indeed, Google's response to patent threats by Apple was to buy the Motorola's rich portfolio of patents and use it to convince Apple to discuss a cross-licence deal.

Most countries that provide financial support for business innovation have not espoused tax credits for R&D. Most countries offer subsidies on the cost of whole projects that meet certain criteria, similar to the National Research Council's Industrial Research Assistance Program (IRAP), which costs about $250 million a year and targets small and medium sized businesses. Such an approach probably entails more bureaucracy, but also more selectivity toward innovations that matter and less bias toward R&D intensive innovation.

Financing Research Conducted in Universities and in Dedicated Research Centers

This type of support, which includes National Research Council intra-mural research and provincial programs, is estimated to cost around $5 billion per year and is related to both basic and applied research. Most of this research contributes to advancements of knowledge. Little of it is tied to actual innovation games, where time, secrecy and agility are essential. In fact, this research is the core of Canada's Science and Technology policy and has little to do with an innovation policy. By all indications, Canada is performing well on this research. On a per capita basis, it is among the top two or three leading countries in the world in terms of the quality and influence of its research (Council of Canadian Academies, 2008). But the results of this research go into the global commons of knowledge, where they represent a relatively small contribution to a global endeavour. Innovators find many ideas in that global commons, but at that stage, the Canadian component is fused with the rest. The link of Canadian research to Canadian innovation is weak at best.

Sector and Project Specific Industrial Support

Provided as loans, matching grants, and defence procurement offsets, this type of support targets projects in selected sectors deemed "strategic": aerospace, defence-related technologies, shipbuilding, pulp and paper, energy, etc. Provinces run small programs in this category, but most of the money is federal, to the tune of $1 billion a year when everything is added up. Big ticket items and large businesses are mostly involved, though small and medium size suppliers also benefit. Most projects that are supported are involved in closed system games, such as a new plane or a new large scale software system. Such support can significantly reduce the risks associated with pushing the envelope innovation projects and thus can stimulate business to invest in innovations in sectors judged strategic for Canada. Most countries are involved in that type of assistance.

Regionally Focused Assistance and Cluster Support

This assistance and support can take many forms, from research subsidies to tax assistance for venture capital and training grants. The goal of replicating Silicon Valley underlies many of these policies. Fortunately, because actual entrepreneurial success is typically one of their building blocks, these policies can indeed strengthen clusters, giving Canada its Technology Triangle, its Silicon Valley North, MaRS, video games in Vancouver and Montreal, optics in Quebec City, etc. However, much of the funding channelled by the regionally focused policies ended up supporting institutional research, and the same comment raised in the previous section about the lack of relation of that research with the innovation process applies.

But this support contributes to the creation of a business environment conducive to innovation. Access to talents and spin-offs in early emerging market games are two critical elements for innovation that the games-of-innovation framework draws attention to. Technology-oriented graduates from local universities are important for fast-growing firms in technological sectors, for specialized firms in the ecosystems of large innovative firms and for their new innovative projects. These graduates, who for all kinds of down-to-earth reasons, have a local bias when they seek employment upon graduation. The placement of their graduates in local firms represents the most important contribution of universities to Canada's innovation performance. Spin-offs, which rely on venture capital, models and pioneering customers are also stimulated by the environment of dynamic clusters. In that regard, the activities of the Business Development Bank and various provincial programs targeting high-potential high-risk entrepreneurial ventures are a positive contribution to innovation. But Canada's innovation problem is much bigger than anything that could flow from the entrepreneurial effervescence in the technology field. VC-supported firms represent a narrow segment of the business population.

The Will to Innovate

None of the above policies effectively tackle the 25-30 per cent gap in Canada's labour productivity level relative to that of the United States. This gap seems to stem not from labour deficiencies and not from a lack of investment, but from the willingness of Canadian business at large to innovate, and develop or adopt superior solutions in their market. Could better competition policies stimulate profitable but complacent Canadian businesses in mature sectors (mostly in services), prodding them to be more innovative? They are the cause of the poor productivity figures of Canada. Can more interregional and more international competition force them to be more innovative, to improve their processes and to differentiate their products? That debate does not really take place in Canada, as it is too often mired in federal–provincial or protectionist squabbles. But there is no doubt that in mature markets, the decision to compete on the basis of differentiated products and of improved processes is the prime driver of innovation strategies.

Better Public Policies

The assessment of Canada's public policies on innovation by filtering them through the game-of-innovation framework raises numerous questions about their effectiveness. Most of the money currently goes to tax credits for industrial R&D and to academic research that may contribute significantly to the advancement of knowledge, but which is not tied to the actual innovation process. This passive but generous promotion of research in universities and in business is a relatively inefficient way of promoting innovation. Industry and project-specific support and regionally focused assistance received much less funding, but are more efficient levers. A broadening of demand-side sector-specific support policies (à la DARPA), common in the United States, Europe and Japan, would be a positive development.

Regionally-focused strategies, with their emphasis on talent development and on entrepreneurial initiatives, can also foster pro-innovation attitudes in local businesses, leading them to invest more in innovation strategies then they would otherwise, making them more active players in whatever innovation games they are involved. Programs that encourage local employment of university graduates could have similar effects. Restructuring the National Research Council along the recommendation of the Jenkins panel, ensuring that some of its institutes work more closely with business, is also likely to represent a more effective use of their research capacity. But again, leveraging R&D has limited impact on the overall innovation strategies of most businesses. Finally, both federal and provincial governments have policies to stimulate venture capital. Part of it targets start-ups in emerging markets, which is good in itself, but given the low probability of the long-term survival of these firms and the small footprint of emerging markets in the total economy, the impact is somewhat limited. Venture capital that targets firms that thrive in the ecosystems of innovators and non-technological businesses is likely to have a greater impact as the odds of survival is higher and their footprint in the economy larger.

Other policies may be made part of a national innovation strategy. Let's consider the ownership of a rapidly growing Canadian business that becomes as a significant player in an emerging market. For instance, should the Investment Canada Act be used to stop a take-over of RIM, if such an event ever occurs? Would it have been a positive development if a Japanese snowmobile manufacturer had taken over Bombardier in 1980, before its diversification into business jets and rail transportation? These are questions which the development of an innovation policy should address.

But a more fundamental observation is the limited leverage that governments have to stimulate innovation. Most business innovations stem from corporate decisions. The cost of developing improved products or processes is a secondary element in such decisions, which bear mostly on the what, when and how to market it, usually as a competitive response. The decision to respond to the competition through an innovation is the fundamental step, and that decision depends on the alternatives and on corporate culture. It is worthwhile investigating whether in Canada, as a general rule, the business environment is characterized by the triple combination of less competitive pressure, more alternatives to innovation and a culture of comfort that does not pressure management to assume the uncertainty of innovation. How can government policies influence these three factors is something we should also ponder. Reducing the cost of innovating through tax credits is probably not very effective. Luring businesses to undertake innovative projects through specific risk-sharing subsidies, as many countries do, is probably more effective, but one has to accept the process, which most Canadians seem reluctant to do.

Governments are also lured by the appeal of breakthrough innovations and by the excitement of new markets, trying to build the next Bombardier (which came out of the snowmobile market) or the next RIM, which is coming out of the emerging smartphone market. But from a public policy point of view, successes in emerging market games are long shots: over a 20 year period these markets grow at frantic rates, and most entrants (and there are quite a few early in the game) will disappear, either by being taken over or through bankruptcy. There were probably more than 20 PC manufacturers launched with great hopes in Canada in the early 1980s, many with the strong support of governments. None survived. Indeed, only a few survived in North America. In biotech, after twenty years during which governments invested several billions of dollars every year to subsidize research in business and universities, there is one Canadian pharmaceutical/biotech company with a market capitalization above one billion dollars, and six with market capitalization between $1 billion and $100 million.[6] Moreover, employment in the more mature side of the pharmaceutical

6 As of March 15th 2012, Valeant has a market capitalization of $16 billion. The others are Paladin ($851 million), QLT ($369 milion), Oncolytics ($356 million), YM ($233 million), Theratechnologies ($150 million), and Cangene ($127 million).

industry is down, and so is industry R&D. The subsidized research may have been quite useful, but it did not translate into innovations and into economic development. That is how challenging emerging markets are.

The game of innovation framework introduces a new perspective to the development of innovation policies by bringing forward the business context which is actually taken into account when decisions to innovate are taken. The development of public policies on innovation will benefit by incorporating this framework into the analysis.

References

Baldwin, John R. and Chowhan, James (2003) *"The Impact of Self-employment on Labour-Productivity Growth: A Canada and United States Comparison,"* Statistics Canada, Micro-economic Analysis Division, Research Paper, Cat. No. 11F0027MIE — No. 016.

Baldwin, John and Wulong Gu (2009) *Productivity Performance in Canada, 1961 to 2008: An Update on Long-term Trends*, Statistics Canada, Cat. No. 15-206-X No. 025, Ottawa, 2009.

Bureau of Economic Analysis (2011) *Information Technology Outlook*, Washington.

Christensen, Clayton M. (1997) *The Innovator's Dilemna*, (Cambridge: Harvard University Press).

Canadian Council of Academies (2008) *2005 Assessment of the State of Canada Science and Technology*, Ottawa.

Council of Canadian Academies (2009) *Innovation and Business Strategy; Why Canada Falls Short*, Report of the Expert Panel on Business Innovation, Ottawa.

Donahoe, Matthew M., Edward T. Morgan, Kevin J. Muck, and Ricky L. Stewart (2010) *Annual Industry Accounts: Advance Statistics on GDP by Industry for 2009 and Revised Statistics for 1998-2008*, Bureau of Economic Analysis, Washington, June.

Government of Canada (2011) *Innovation Canada: A Call to Action*, Expert Panel Report, (Jenkins report).

Jaruzelski, Barry, John Loehr, John and Richard Holman (2006) *Smart Spenders: The Global Innovation 1000*, Booz & Co.

Miller, Roger and Marcel Côté (2012) *Innovation Reinvented: Six Games that Drive Growth*, (Toronto: University of Toronto Press).

Nicholson, Peter (2009) "Innovation and Business Strategy: Why Canada Falls Short," *International Productivity Monitor*, Number 18, Spring, pp. 51-71.

OECD (2005) *The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data*, (The Oslo Manual), Paris.

Pélissié du Raussas, Matthieu (2011) *Internet Matters: the Net's Sweeping Impact on Growth, Jobs and Prosperity* (New York: McKinsey Global Institute).

The Effects of Computer Technologies on the Canadian Economy: Evidence from New Direct Measures

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ABSTRACT

New indicators of technical change in the field of computers based on new titles held by Canadian libraries are presented, and are used to demonstrate that a positive computer technology shock in Canada increases hours worked, output, and productivity in the short run. These measures indicate, first, that advances in the implementation of computer technology in Canada are largely influenced by innovations in the United States; and second, when compared to a United States-based indicator, that a gap emerged between United States and Canadian-held titles around the time that the productivity gap emerged between the two countries. Given that a strong, causal relationship is found to exist between the new indicators and total factor productivity, this evidence provides additional support for the hypothesis that crosss-border differences in the development and use of new computer technologies play a key role in explaining Canada's productivity gap with the United States.

RÉSUMÉ

De nouveaux indicateurs du changement technique dans le domaine de l'informatique, basés sur les nouveaux titres des bibliothèques canadiennes, sont présentés et montrent qu'un choc technologique positif dans le domaine de l'informatique au Canada accroît à court terme le nombre d'heures travaillées, les résultats et la productivité. Ces mesures indiquent, premièrement, que les progrès de l'application de la technologie informatique au Canada sont en grande partie influencés par les innovations aux États-Unis et, deuxièmement, que lorsqu'elles sont comparées à un indicateur américaine, un écart apparaît entre les titres dans les bibliothèques canadiennes et américaines à peu près au moment où l'écart entre la productivité des deux pays se fait jour. Compte tenu de l'existence d'une forte relation de cause à effet entre les nouveaux indicateurs et la productivité totale des facteurs, ces observations renforcent l'hypothèse selon laquelle les différences entre le développement et l'utilisation des nouvelles technologies informatiques dans les deux pays jouent un rôle essentiel pour expliquer l'écart de productivité du Canada.

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Computer technologies are often viewed as a key contributor to productivity growth in advanced industrial countries such as the United States and Canada.[2] It follows that cross-country differences in the development and use of these technologies may at least partially account for cross-country productivity differentials. This is particularly relevant for Canada and the United States because it is frequently argued that the growth in the productivity gap between these two countries is attributable to the more rapid adoption of information technologies in the latter than in former.[3] As compelling as this argument may appear, the lack of direct measures of technical change in this area has made it difficult to provide a quantitative assessment of either the impact of computers on economic activity in the two countries or the causal link between differences in their adoption rates and productivity differentials. In short, if we want to quantify the impact on these economies of innovations in this area, we must be able to measure them.

As it happens, that is precisely what we propose to do in this article. We first present new direct measures of technological change in the field of computers in Canada for the 1950-2005 period, based on the number of new computer-related titles held by Canadian libraries[4] and then use them to show that: (1) the United States is the principal source of advances in computer technology in Canada; (2) the rate of adoption of new computer technologies in the United States began to surpass that of Canada in the 1970s; and (3) a strong relationship exists between computer innovations and productivity, GDP, and hours worked.[5] Together, these findings provide empirical support for the hypothesis that cross-border differences in the commercialization and rate of adoption of new computer technologies have played a key role in the widening of the Canada-U.S. productivity gap.

The article is divided into four sections. The first section discusses the indicators and their properties. Section two reports the results of our regressions. Section three discusses the potential link to the Canadian and U.S. productivity gap. The fourth and final section concludes.

The Indicators

Most would agree that a good direct measure of technical change should, at a minimum: (1) be available at least on an annual basis over a long time horizon; (2) be objectively determined; (3) weight different technologies according to their importance; and (4) tap into the full range of new advances. Moreover, for many purposes we would add a fifth requirement – that the indicator capture innovations at the moment of their commercialization. This is important for two reasons. First, much of the impact on output, productivity and employment occurs through the adoption of new technologies. Second, unanticipated technology shocks, an important feature of many economic models, are generally identified not by the timing of the invention or even the patenting of a new technique but by its use.

Our new book-based indicators possess all of these features. They are: (1) objective because they are determined by cataloguing criteria established and followed consistently by librarians; (2) quantifiable because they are based on the number of new titles; (3) weighted because

2 See, for example, Alexopoulos (2011), Alexopoulos and Cohen (2011), Oliner *et al.* (2007), Khan and Santos (2002), Stiroh (2002), Van Ark *et al.* (2003), and Sharpe (2006), and the citations within.

3 See Basu *et al.* (2003) for an interesting study of differences in productivity growth between the United States and the United Kingdom and the relationship to IT technologies.

4 The approach, developed by Alexopoulos (2011), was applied initially to the United States.

5 In what follows we use the terms book-based and publication-based interchangeably. The indicators are primarily based on new manuscripts. However, pamphlets that are catalogued are included. Serial publications and continuing resources are, by and large, excluded from the counts.

more titles are published on important advances than on lesser ones; and (4) broad-based because new titles appear on all innovations of any significance.[6] Finally, new publications, for good economic reasons, are timed to coincide with the commercialization of new products or processes. The innovating companies want to spread the word about their new devices – what they are, how to use and maintain them, – while publishers and their writers want to profit from the market demand for information about these new technologies. In all cases timing is critical – too early and there is no market, too late, and the market is fully served. Although there are clearly other means aside from print to convey information about new technologies, our findings (Alexopoulos (2011) and Alexopoulos and Cohen (2009, 2011)) suggest that these book-based indicators provide a compelling way to quantify technical change and to evaluate its impact on the economy.[7]

Description of the Indicators

Although we focused in our previous work on the United States, it is possible to use a similar methodology (developed in Alexopoulos (2011)) to create comparable technology indicators for Canada. This is because Canadian libraries also use **MA**chine **R**eadable **C**ataloging (MARC) records to run their online catalogues.[8] As is well-known, computer-related innovations in Canada are an amalgam of home-grown and imported advances, much more so than, for example, in the United States. Moreover, Canada does not have a library of the size and scope of the Library of Congress in the United States. For these reasons, we reshaped our approach to ensure that we capture the full range of foreign and domestic developed computer technologies commercialized in Canada. In particular, we used information from the catalogues of 1,062 Canadian libraries covered in the WorldCat database of the Online Computer Library Centre (OCLC) on the number of new computer titles published between 1950 and 2005, without regard for country of publication.[9] While not all Canadian libraries are members of OCLC, the membership includes the National Library of Canada, the country's largest public libraries (e.g. those in Toronto, Montreal and Vancouver), and all major university libraries. As such, the combined MARC records of the member libraries provide a comprehensive list of all major new computer-related titles available to the Canadian public.

Even though the MARC records were designed to serve the online cataloguing needs of librarians, it turns out , because of the large amounts of data buried in them, that they are also a potentially powerful research device for, among others, economists. For example, each MARC record contains information on the type of book (for example, a new title, a new edition of an existing one, a reprint, or a translation), the country and language of the publication, the publisher, the Library of Congress and/or the Dewey Decimal Classification Code, and a list of major subjects treated in the book. These data enable us to com-

6 Alexopoulos (2011), and Alexopoulos and Cohen (2009, 2011) also present evidence that the book publication measures are related to traditional measures of technical change such as R&D, patents, major innovations, and journal article counts in the United States.

7 Although some may be concerned that changes in the number of titles is driven by ups and downs in the publishing industry, our findings in the papers cited indicate that the patterns, on the whole, appear to be dictated by changes in innovations. Finally, although cataloguing and keyword assignment are potentially subject to error, there is no reason to believe that misclassification is a problem.

8 See Appendix A for an example of a MARC record.

9 The data used for this research were based on a snapshot of the OCLC's WorldCat database as of the middle of 2010. We took 2005 as our cut-off date to avoid any biases created by the backlog of uncatalogued titles.

Chart 1
Indicators of Computer-Related Titles by Copyright Date

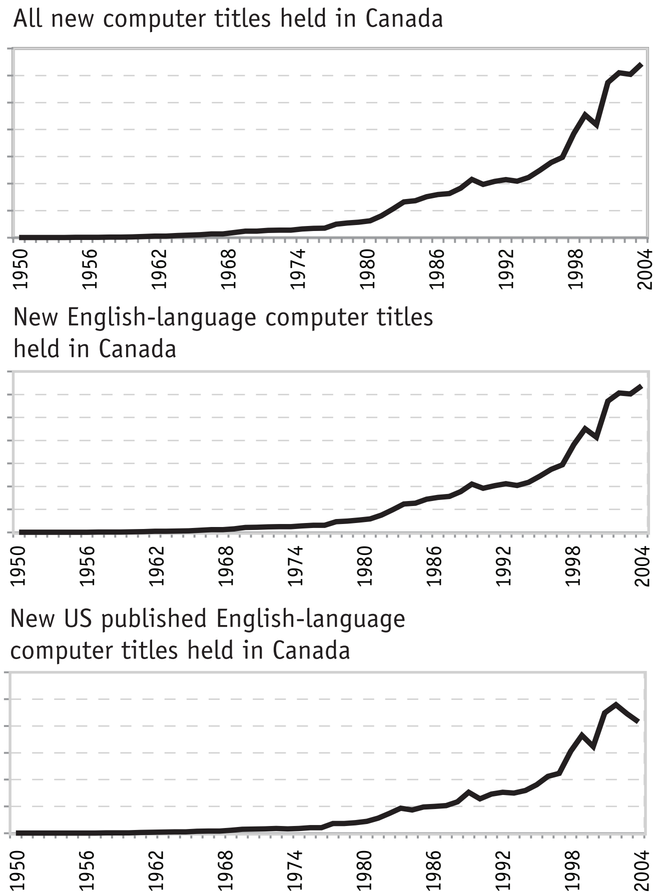
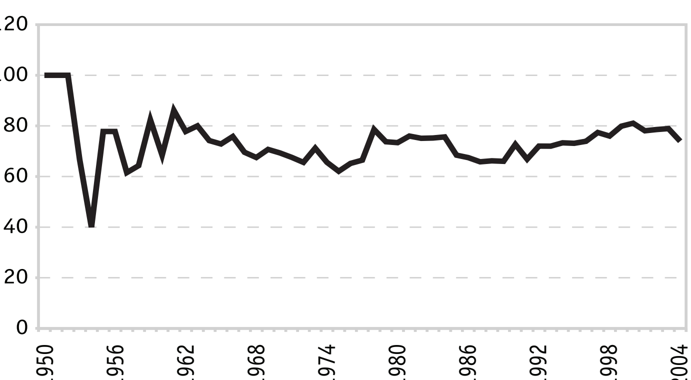


Chart 2
Fraction of English-Language Held Computer Books in Canada Published in the United States (per cent)



pile a list of new titles published each year on computers and computer science that are held by Canadian libraries in the sample between 1950 and 2005.[10] To ensure that our titles actually represent the appearance of new technologies, we eliminate from the sample all books that include history as a descriptor since they, almost by definition, focus on the past not the present. Thanks to the richness of the MARC records, we are able to create, as can be seen in Chart 1, three slightly different indicators for the purposes of this analysis: the first includes all books held in the field by the Canadian libraries regardless of the language or country of publication; the second excludes non-English language titles; while the third is limited to English language titles published in the United States.

In all cases, the indicator includes manuals and books that deal with new computer technologies that describe their nature and function, how they work, and how to use or repair them. Some of the titles are published or sponsored by the innovator or the company that developed it, while others are written by third parties who hope to profit from sales of the book. As noted earlier, all groups have an economic incentive to ensure that the publications appear as close as possible to the commercialization date of the new technologies. At the same time, libraries, seeking to serve their market, will then purchase the books they believe will be demanded and used by their patrons. For this reason we would expect to observe a close chronological coincidence between the copyright date of the first book on a new technology that appears in a library (as captured by the WorldCat database) and its commercialization date as reported in other source material. The results in Table 1, based on the dates for a sample of computer innovations commercialized in Canada and the United States, confirms this timing.

10 See Appendix B for a description of the Dewey Decimal Classifications and Library of Congress Classifications associated with the computer and computer science classifications included in the counts.

Table 1
Comparison of Dates for Selected Computer Innovations

Innovation	Date of innovation	Country of Invention	Commercialization Date in the United States	First American Book Date	Commercialization Date in Canada	First Canadian Book Date
Windows	Nov. 1983	US	Nov. 1985	1985	Nov 1985[1]	1986
Lotus	Nov. 1982	US	Jan. 1983	1983	Feb 1983[2]	1983
Apple II+	1978	US	June 1979	1979	1979[3]	1979
Macintosh	Jan. 1984	US	First Quarter 1984	1983	Jan 1984[4]	1984
Lisa	1978	US	Jan. 1983	1983	April 1983[5]	1984
IBM PC	July 1980	US	Aug. 1981	1982[6]	Aug 1981[7]	1982
IBM PC/AT	Aug. 1984	US	Fall 1984	1985[8]	Fall 1984[9]	1985
Commodore 64	Jan. 1982	US	Nov. 1982	1982	Sept 1982[10]	1982
PAT (OpenText)[11]	1989	Canada	1992	1993	by 1991	1992
Corel Draw[12]	1987-1989	Canada	1989	1988	Jan 1989	1988
Sinclair ZX80[13]	1980	UK	Fall 1980	1981	Late 1980	1980

1. http://www.guidebookgallery.org/ads/magazines/windows/win10-powerwindows-8
2. Michael Kieran, "Programs for micros enter new generation," *The Globe and Mail*, pp. R.12-R.12, Feb 28, 1983
3. See comment on http://www.facebook.com/torontostar/posts/227813607276004 by J. Lyng, a resident of Toronto, and blog post on http://taoofnews.com/2011/01/25/thirty-years-in-new-media/
4. Jonathan Chevreau, "Xerox Canada will carry Lisa, Macintosh machines," *The Globe and Mail*, B.14, May 11, 1984
5. Michael Kieran, "Programs for micros enter new generation," *The Globe and Mail*, pp. R.12-R.12, Feb 28, 1983
6. WorldCat points to a scanned book captured by Google that is entitled Technical specifications under the series: IBM Personal Computer. Hardware reference library published by IBM.
7. Jonathan Chevreau, "Computerland chief expects IBM entry to add credibility to personal market," *The Globe and Mail*, pp. B.9-B.9, Aug 27, 1981
8. While not physically held in a library, OCLC records point to a technical publication by IBM for this computer with a copyright date 1984.
9. Jonathan Chevreau, "IBM launches new 20-megabyte PC unit," *The Globe and Mail*, pp. B.1-B.1, Aug 15, 1984
10. Jonathan Chevreau."Price war is expected in personal computers" *The Globe and Mail*, pp. B 15, Sept. 8, 1982
11. http://www.opentext.com/2/global/company/company-history.htm#ecml
12. http://www.fundinguniverse.com/company-histories/Corel-Corporation-Company-History.html and American review of the technology by S. Rosenberg, "Corel Draw shows great promise" Byte Magazine, June 1, p. 213.
13. http://en.wikipedia.org/wiki/Sinclair_ZX80 and http://maben.homeip.net/static/S100/sinclair/brochure/Sinclair%20ZX80%20Jan%2081%20Byte%20review.pdf

Notes: First book dates correspond to the copyright date of the first book held by a library in the OCLC WorldCat database. See Alexopoulos and Cohen (2011) for sources of the US innovation and commercialization dates for Windows, Lotus, Apple II+, Macintosh, Lisa, IBM PC, IBM PC/AT and Commodore 64, and the footnotes for information used for the Canadian commercialization dates and the dating of PAT, Corel Draw and the Sinclair ZX80.

Table 1 also demonstrates the fluidity with which computer technologies flow across borders. It appears that the technologies developed in the United States and the United Kingdom were quickly embraced in Canada. For example, the commercialization dates in Canada for computer software programs such as Lotus 1-2-3, and Windows were virtually identical to those in the United States. The same is true for computer hardware such as the Apple II+, Commodore 64, IBM PCs, Sinclair, and the Macintosh all of which appear almost simultaneously in the two countries. As it happens, the flow was not uni-directional. Canadian innovations like CorelDraw, developed by Corel, and PAT, developed by Open Text Corporation, were adopted by American firms soon after their Canadian release dates.

A close relationship can also be observed in Table 1 between first commercialization dates and copyright dates (book dates in the table), independent of the location of the innovations. For all of these cases, there is never more than a year's difference between the copyright date and the year of its adoption in either the United States or Canada. In other words, the appearance of a computer-related book in a Canadian library provides a good indicator of the initial arrival (commercialization) of the new technology in the country. Moreover, as we have shown elsewhere (Alexopoulos (2011), and Alexopoulos and Cohen (2011)), new titles are associated with the introduction of new processes or products and not their diffusion. Our indicators, in short, should provide a good measure of computer innovations in Canada. We turn now to the central question of this article – what impact did these new technologies have on economic activity in Canada?

Output, Productivity, and Technical Change

We have used similar indicators in other papers (Alexopoulos (2008, 2011), and Alexopoulos and Cohen (2009 and 2011)) to explore the relationship between innovative activity in a variety of fields, output, productivity, and employment in the United States, drawing on the MARC records of the Library of Congress, Amazon.com's booklists, and R.R. Bowker's publishers' lists. In particular, we have found, first, that new computer technologies have been an important determinant of productivity growth in the United States during the post WWII period, and second, that computer-driven technology shocks have led to short run increases in productivity, employment, and output. We repeat the analysis using the new Canadian indicators and ask: do we observe the same relationships in Canada?

To answer this question, we estimate the following bi-variate VARs:[11]

$$Y_t = \alpha+\gamma t+\rho Y_{t-1} +\varepsilon_t \qquad (1)$$

where $Y_t = [\ln(Z_t), \ln(X_t)]'$, with Z_t being our measure of aggregate output or total factor productivity (TFP), and X_t being the number of new computer titles.[12] As in Alexopoulos (2011) and Shea (1998), our computer indicator is ordered last in the VAR and a computer technology shock is identified by assuming that it affects the Z variables with a one year time lag. Our measure of aggregate TFP is from Madsen (2007) while hours worked and real GDP are based on data from Maddison (2010), the Historical Statistics of Canada, and CANSIM. Chart 3 displays the impulse responses to a one standard deviation computer technology shock (as identified by our indicator), and 90 per cent confidence intervals. Table 2 reports the Granger-causality

11 A vector autoregression (VAR) is a popular statistical model used to capture the linear interdependencies among multiple time series. As above, each of the variables in the model is represented by an equation linking the variable's current value to lags of its own values, the lags of all the other variables in the model and other deterministic series such as a time trend.

12 Our choice of this specification is driven by two main considerations. First, it is comparable to the specification used in our earlier work focusing on the United States. Second, Gospodinov, Maynard and Pesavento (2011) highlight problems associated with choosing a specification based on univariate unit root tests and demonstrate that severe biases can be introduced by removing low frequency movements by estimating VARs in first differences.

Chart 3
Impulse Response Functions- Bi-Variate VAR

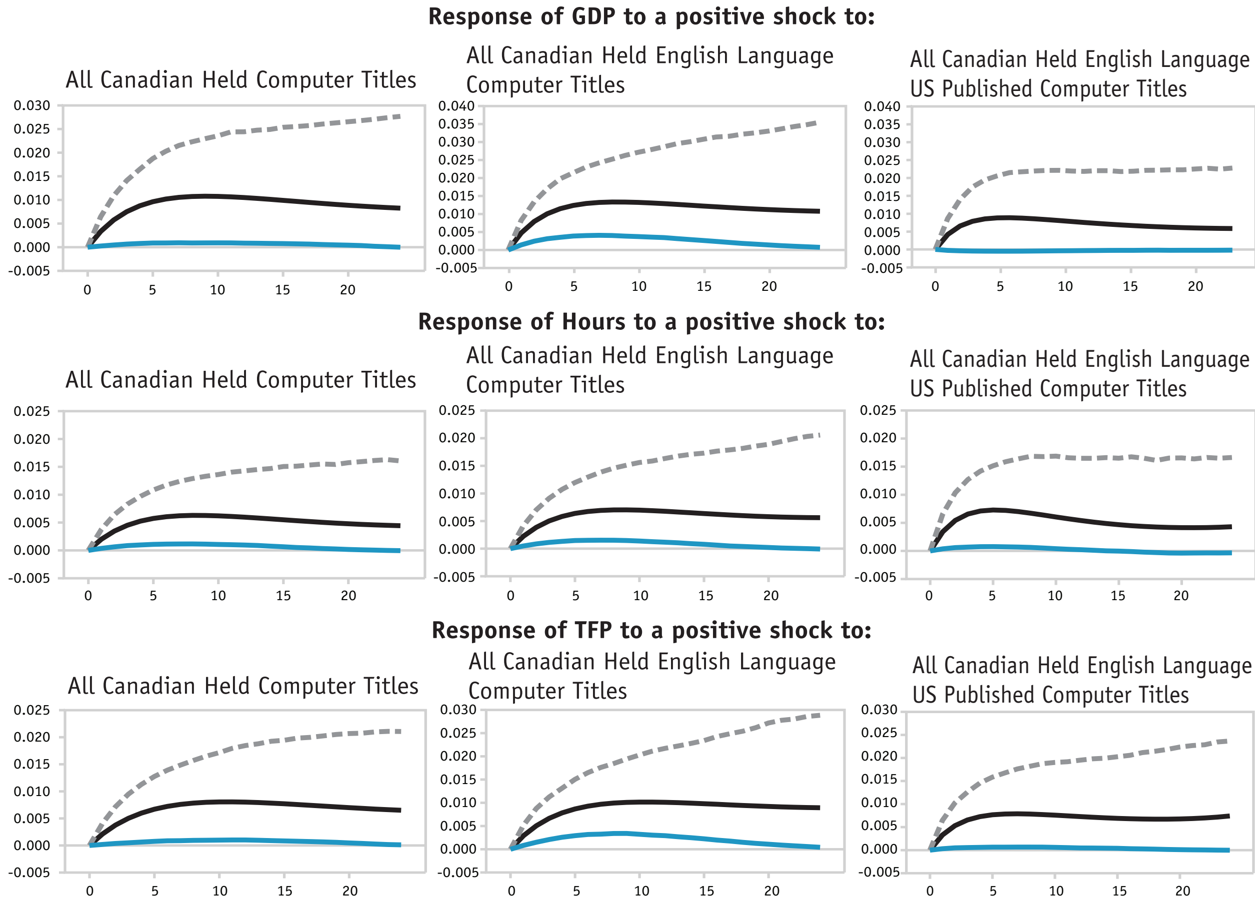


Table 2
P-values of Granger Causality Tests

Technology Indicator	Do Computer Technologies Granger-Cause GDP?	Does GDP Granger-Cause Computer Technologies?	Do Computer Technologies Granger-Cause TFP?	Does TFP Granger-Cause Computer Technologies?	Do Computer Technologies Granger-Cause Hours?	Do Hours Grange-Cause Computer Technologies?
All Canadian held computer books (COMPALL)	0.071	0.795	0.059	0.914	0.046	0.789
All Canadian held computer books in English (COMPENG)	0.019	0.518	0.018	0.856	0.040	0.757
All Canadian held computer books in English published in the United States(COMPUS)	0.111	0.168	0.064	0.315	0.061	0.850

Notes: For all cases $Y_t = \alpha + \gamma t + \rho Y_{t-1} + \varepsilon_t$, where $Y_t = [\ln(GDP_t), \ln(X_t)]'$, $Y_t = [\ln(TFP_t), \ln(X_t)]'$ or $Y_t = [\ln(Hours_t), \ln(X_t)]'$ and X_t is the value of the indicator at time t.

tests, and Table 3 reports the variance decompositions for the bi-variate cases.

The results echo those for the United States reported in Alexopoulos (2011) and Alexopoulos

Table 3

Per cent of Variation Due to Technology in Two Variable VARs

	Years	ln(GDP)	ln(TFP)	ln(Hours)
All Canadian held computer books (COMPALL)	3	3.379	2.821	2.158
	6	12.593	11.791	9.124
	9	21.117	21.433	16.531
	12	27.353	29.247	22.293
All Canadian held computer books in English (COMPENG)	3	6.888	5.528	2.732
	6	22.359	21.275	11.474
	9	33.719	35.360	20.510
	12	40.779	45.048	27.339
All Canadian held computer books in English published in the US (COMPUS)	3	3.803	5.193	5.121
	6	8.987	13.650	14.785
	9	11.715	18.697	20.775
	12	13.135	21.506	23.788

Notes: These decompositions are based on bi-variate VARs where ln(GDP), ln(TFP) and ln(L) are ordered first. For the cases of using the new book measures and patents the VAR takes the form $Y_t = \alpha+\gamma t+\rho Y_{t-1} +\varepsilon_t$ where $Y_t = [\ln(GDP_t), \ln(X_t)]'$, $Y_t = [\ln(TFP_t), \ln(X_t)]'$ or $Y_t = [\ln(L_t), \ln(X_t)]'$ and X_t is the value of the indicator at time t.

and Cohen (2011). We find, first, that computer-related technical change, as measured by our indicators, had a significant impact on output, hours worked, and TFP in post-WWII Canada. Second, our Granger-causality tests indicate that causality runs from computer-based innovations to output, hours, and TFP and not the other way round. And, third, of the three series (all computer-related books, all English language titles, and English language, U.S.- based publications), it is the second that has the strongest influence on output, hours, and TFP.

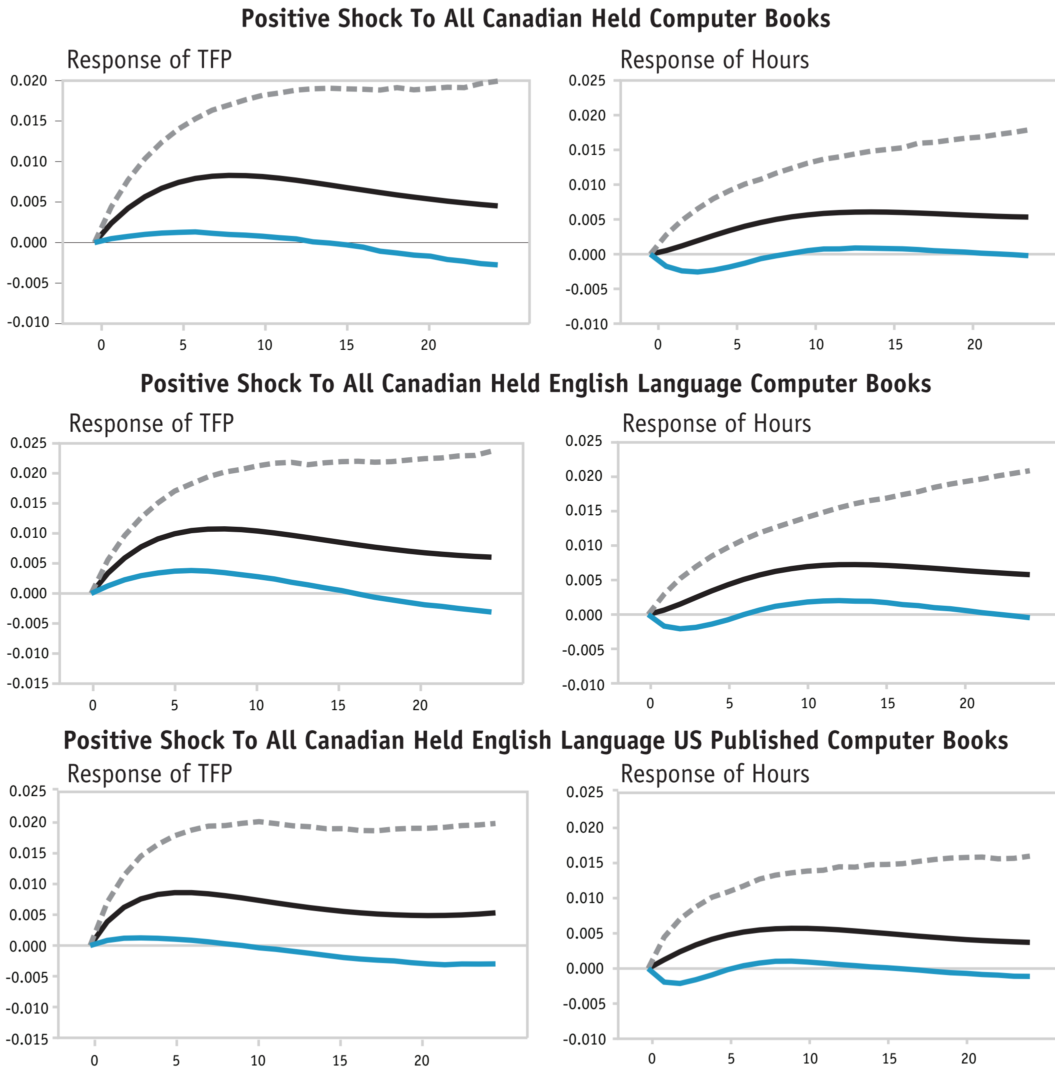
The impulse response functions associated with our VARs can be seen in Chart 3. As the first panel in Chart 3 shows, GDP significantly rises above trend for approximately 25 years following a positive shock to computer technologies (as identified by our indicators) with the peak effect occurring after approximately seven years. Panels 2 and 3 demonstrate that at least part of the increase in output is attributable to rises in hours worked and TFP – both of whose responses are similar to that of GDP.[13] Each of these variables significantly rise for 15 to 25 years with their peak effect occurring between years 5 and 7. Of equal interest, the effects for all of the variables are roughly the same for all three indicators.

The variance decompositions are reported in Table 3. We find, first, that in the initial years the impact of technical change in computers on our three variables is relatively weak. To be more precise, in year three, the indicators accounted for 3.4–6.9 per cent of the variation in GDP, 2.8–5.5 per cent of the variation in TFP and 2.2–5.1 per cent of the variation in hours. By year 6, however, the effect has changed quite noticeably: technical advances in computers now account for 9.0–22.0 per cent of the variation in GDP, 11.8–21.3 per

13 While the analyses in Alexopoulos (2011) and Alexopoulos and Cohen (2011) are based on a slightly different time period, 1955-1997 and 1980-2008, their findings suggest the peak impacts for a computer innovation occur earlier in the United States.

Chart 4

Impulse Response Function: Tri-Variate VAR



cent of the variation in TFP and 9.1–14.8 per cent of the variation in hours. By year 12, the levels have jumped again: 13.1–40.8 per cent of the variation in GDP, 21.5–45.0 per cent of the variation in TFP and 22.3–27.3 per cent of the variation in hours.[14] In general, the impact of computer technologies on the three variables is largest at medium-run horizons. Second, the indicators based on new English language computer titles account, on the whole, for a much larger percentage of the variance in our three variables than do the other two.

Table 4 and Chart 4 report the variance decompositions and impulse responses related to the tri-variate VAR:

$$Y_t = \alpha+\gamma t+\rho Y_{t-1} +\varepsilon_t \qquad (1)$$

where $Y_t = [\ln(TFP_t), \ln(Hours_t), \ln(X_t)]'$. As above, the technology indicators are ordered

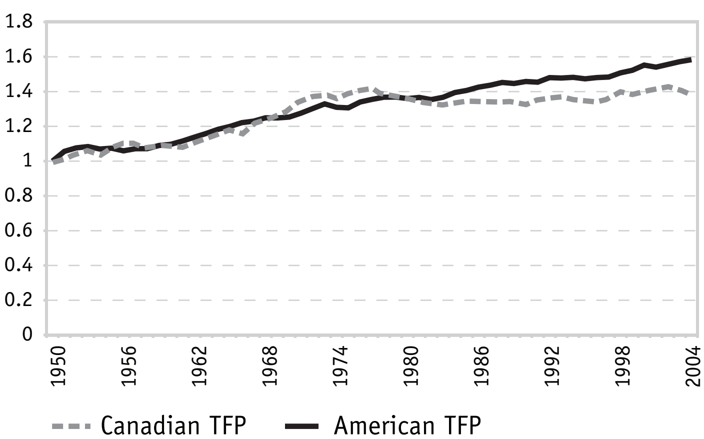
14 The variation in GDP and TFP attributable to computers reported by Alexopoulos (2011) and Alexopoulos and Cohen (2011) are of similar magnitude. However, for the United States, the computer innovations tend to explain a larger share of the variance in years 3-6.

Table 4
Per cent of Variation Due to Computer Technologies in the Tri-variate VARs

	Horizon (Years)	ln(TFP)	ln(Hours)
All Canadian held computer books (LNCOMPA)	3	3.368	0.256
	6	13.311	2.715
	9	23.273	8.010
	12	30.742	14.239
All Canadian held computer books in English (LNCOMPE)	3	7.136	0.421
	6	25.226	4.658
	9	39.543	13.441
	12	48.307	22.863
All Canadian held computer books in English Published in the US (LNCOMPUE)	3	6.571	1.119
	6	15.683	6.110
	9	20.348	11.656
	12	22.568	15.515

Notes: For all cases $Y_t = \alpha+\gamma t+\rho Y_{t-1} +\varepsilon_t$, where Y_t = [ln(TFP_t), ln($Hours_t$), ln(X_t)]′ and X_t is the value of the indicator at time t.

Chart 5
Total Factor Productivity in Canada and the United States, 1950-2005 (1950=100)



Source: The TFP measures for the total economy are from Madison (2007).

last. Again, we find evidence that a positive computer technology shock significantly increases productivity and hours worked. However, the confidence intervals for this case do not exclude the possibility that hours worked may initially decrease immediately following the shock. On the other hand, the results in Table 4 do confirm that new computer technologies play a strong role in productivity movements and a moderate one in variations in hours worked in the medium run.

Canadian Productivity and the U.S.-Canada Productivity Gap

In Chart 5, we present Canadian and American TFP indices from Madsen (2007). Two trends are apparent. First, his estimates suggest that Canadian TFP in 2005 was approximately the same as it was in the mid-1970s. Second, starting in the late 1970s, Canada's TFP growth failed to keep pace with that of the United States, giving rise to a well-known productivity gap.[15]

On the face of it, the first trend would seem to be inconsistent with the analysis in the previous subsection. In addition, it appears to be at odds with the upsurge in computer titles held in Canada and, accordingly, with the apparent advances in computer technology in this country. As it happens, the problem lies not with the data or with our argument but with the misunderstanding that TFP is a proxy for technological innovation. As we all know but often forget, TFP is a residual that contains all those factors other than labour and capital that affect GDP growth. These include, among other things, changes in scale economies, organizational capital, utilization rates, measurement errors and so on, some of which could easily affect the size and rate of change of the residual. The bottom line, for our purposes, is that TFP does not measure pure technical change – which is exactly what our book based indicator is capturing. Moreover, although computer-based technical change did

15 This gap is also seen in labour productivity measures.

play an important role in driving productivity advances in Canada, there were other, counterbalancing forces at work as well. Although unpacking the contents of the residual exceeds the scope of this article, it is a worthwhile project for future research.

As for the second trend, the productivity gap has, naturally enough, attracted the attention of Canadian academics and policy makers.[16] The central questions are the obvious ones – what caused the gap and why has it grown? The answers matter for at least two reasons. First, we cannot begin to address the problem until we identify its source and, second, our ability to compete with our neighbor to the south is closely linked to the relative productivity in the two countries.

Results reported in papers such as Sharpe (2010), Rao (2011), Rao *et al*. (2004), Rao and Tang (2001) and Van Ark *et al.* (2003) suggest that differences in the use and the rate of adoption of information technologies, especially computers, in the two countries are likely a major contributor to gap. While there are always issues with cross-country comparisons, both our metrics, and our overall findings tend to support this view. First, as noted earlier, technological advances in the field of computers have had a significant impact on Canadian productivity. Moreover, as reported in Alexopoulos (2011) and Alexopoulos and Cohen (2011), a similar relationship can be observed in the United States. It follows, then, that if there were a gap in the adoption of new computer technologies between the two countries, this may have been a non-trivial contributor to the productivity gap.

The question is: did such a gap exist? Cross border data on ICT investment in Sharpe (2010) points to a gap, as does our new book-based indicators. Specifically, Chart 6 shows the number of new computer titles held by libraries in the United States as recorded by OCLC alongside the number of new computer titles held by Canadian libraries. It shows that a gap begins to emerge in the early 1970s.[17] A similar pattern can be seen in Chart 7, based on indicators created from the holdings of the largest library in the United States, the Library of Congress, and the largest in Canada, the University of Toronto

Chart 6
New Computer Books Held in Canada and the United States by Copyright Date

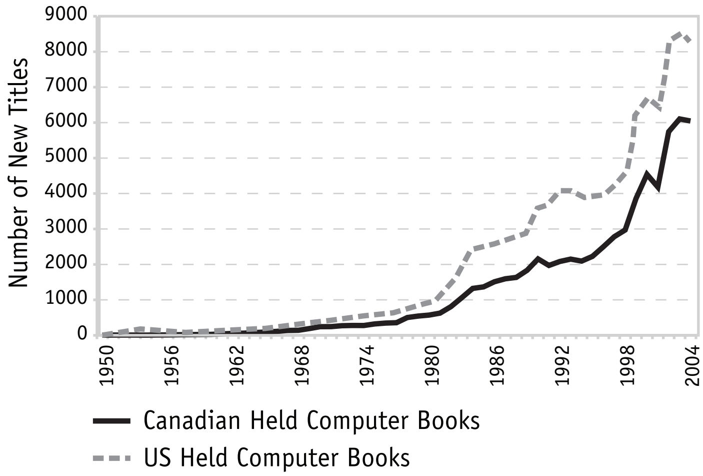
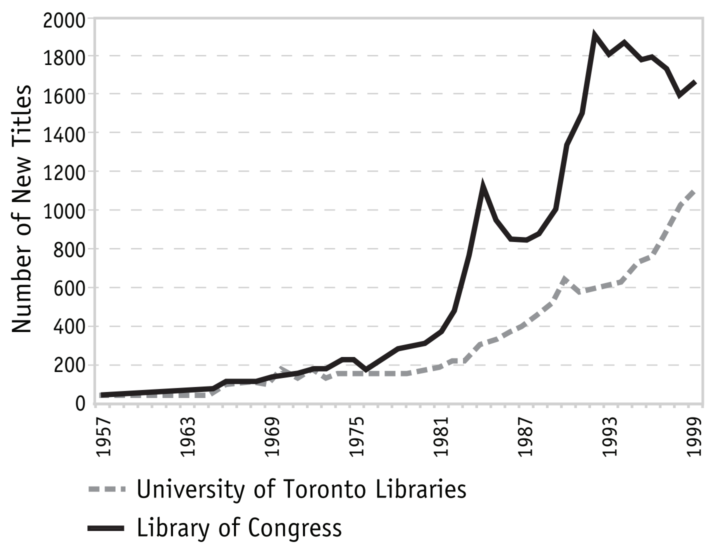


Chart 7
New Computer Titles by Copyright Date



16 See, for example, Rao and Tang (2001), Rao *et al.* (2004, 2008), Baldwin, Gu and Yan (2008), and Rao (2011).

Libraries.[18] Since our VAR results suggest that a lag exists between the commercialization of new computer technologies (as measured by our new indicators) and their impact on productivity, the appearance of a productivity gap in the 1980s is perfectly consistent with the emergence of an adoption gap a few years earlier.[19] In short, the computer-related technology gap measured by our book-based indicators does appear to have contributed to the emergence of the productivity gap beginning in the 1980s.[20]

Conclusion

In this article, we draw on the holdings of Canadian libraries to develop new book-based indicators of technical change in the field of computers for the years 1950-2005 and use them to determine the impact in Canada of technological advances in this area on output, productivity, and employment. As we have argued elsewhere (Alexopoulos (2011, 2008) and Alexopoulos and Cohen (2009, 2011), these new indicators resolve many of the problems that plague traditional measures of innovative activity such as patent citations and research and development expenditures. They also have the additional advantage that because they are consistent across countries as well as over time, they facilitate international time series comparisons. We are able to show, for example, that most of the computer innovations identified in publications held in Canada actually originate in the United States. More, we can demonstrate, using VARs, that similar to our results for the United States, positive computer-related technology shocks in Canada lead to increases in GDP, TFP and hours worked in the short and medium run. Finally, we can make use of our new approach to show that starting in the 1970s, the number of new computer titles in Canada began to lag significantly the number in the United States (the appearance, our indicators suggest, of a technology gap), contributing a decade or so later to the emergence of a productivity gap between the two countries. This finding still leaves open the question of why the technology gap emerged in the first place, but with the identification of this problem, we hope policy makers can take steps to address it.

17 One might be concerned that funding differences could affect the comparability of the indicators across the two countries. However, statistics available from http://www.oclc.org/reports/escan/economic/educationlibraryspending.htm suggest that Canada spends slightly more per capita (4.6 per cent) on its library collections than does the United States, and more as a fraction of GDP (0.20 per cent versus 0.12 per cent). Given that all major U.S. and Canadian libraries are represented in our sample, and that the budgets are sufficient to allow Canadian libraries to accumulate in aggregate the same titles as their American counterparts, we believe the indicators do provide important information about the knowledge gap.

18 The University of Toronto Libraries has one of the largest collections in North America. According to statistics based on the number of titles and volumes held, its collection is approximately 53 per cent of the size of the Library of Congress despite the fact that the Library of Congress serves a much larger population than the University of Toronto Libraries.

19 It should be noted that a widening productivitty gap beween Canada and the United States does not require that there be a growing gap in computer titles in relative terms. The current level of TFP depends on the lags of all of the new titles in the economy (not in relative terms). The fact that the Americans are still accumulating more new titles would imply that the gap should be there. However, as the current gap on the new books shrinks, the gap would widen less provided that the coefficients on the lagged titles are the same in the two countries.

20 Alexopoulos and Tombe (2011) identify a gap in management techniques which may also contribute to the presence of the gap.

References

Alexopoulos, Michelle (2008) "Extra! Extra! Some positive technology shocks are expansionary!" *Economics Letters*, Vol. 101, pp. 153-156.

Alexopoulos, Michelle (2011) "Read All About it!! What happens following a technology shock?" *American Economic Review*, Vol. 101, No. 4, pp. 1144-79.

Alexopoulos, Michelle and Jon Cohen (2009) "Measuring our Ignorance, One Book at a Time: New Indicators of Technical Change, 1909-1949," *Journal of Monetary Economics*, Vol. 56, pp. 450-70.

Alexopoulos, Michelle and Jon Cohen (2011) "Volumes of Evidence: Examining Technical Change Last Century Through a New Lens," *Canadian Journal of Economics*, Vol. 44, No. 2, pp. 413-450.

Alexopoulos, Michelle and Trevor Tombe (2011) "Managerial Knowledge and Canadian Productivity," University of Toronto Working Paper.

Baldwin, John R., Wulong Gu and Beiling Yan (2008) "Relative Multifactor Productivity Levels in Canada and the United States: A Sectoral Analysis," *Statistics Canada Research Paper*, Catalogue No. 15-206-X, No. 019

Basu, S., J. Fernald, N. Oulton and S. Srinivasan (2003) "The Case of the Missing Productivity Growth: or, Does Information Technology Explain Why Productivity Accelerated in the US but not the UK?" *NBER Macroeconomics Annual*.

Gospodinov, N., A. Maynard and E. Pesavento (2011) "Sensitivity of Impulse Responses to Small Low-Frequency Comovements: Reconciling the Evidence on the Effects of Technology Shocks," *Journal of Business & Economic Statistics*, Vol. 29, No. 4, pp. 455-467.

Khan, H. and M. Santos (2002) "Contribution of ICT use to Output and Labour Productivity Growth in Canada," Bank of Canada Discussion Paper 2002-07.

Library of Congress Classification. A-Z, Library of Congress, Cataloguing Distribution Services, Washington, D.C. Various years.

Maddison, A. (2010) *Statistics on World Population, GDP, Per Capita GDP 1-2008 AD*. Groningen Growth and Development Center.

Madsen, J. (2007) "Technology spillover through trade and TFP convergence: 135 years of evidence for the OECD countries," *Journal of International Economics*, Vol. 72, No. 2, pp. 464-480.

Oliner, S., D. Sichel and K. Stiroh (2007) "Explaining a Productive Decade," B*rookings Papers on Economic Activity*, Vol. 38, No. 1, pp. 81-152.

Rao, Someshwar (2011) *Cracking Canada's Productivity Conundrum*. IRPP Study 25 (Montreal: Institute for Research on Public Policy).

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

Rao, Someshwar, Jianmin Tang and Weimin Wang (2004) "Measuring the Canada-U.S. Productivity Gap: Industry Dimensions," *International Productivity Monitor*, No. 9, Fall, pp. 3-14.

Rao, Someshwar, Jianmin Tang and Weimin Wang (2008) "What Explains the Canada-U.S. Labour Productivity Gap?" *Canadian Public Policy*, Vol. 34, No. 2, pp. 163-92.

Sharpe, Andrew (2006) "The Relationship between ICT Investment and Productivity in the Canadian Economy: A Review of the Evidence," Research Report 2006-05 (Ottawa: Centre for the Study of Living Standards)

Sharpe, Andrew (2010) "The Canada-U.S. ICT Investment Gap in 2008: Gains in Communications Equipment and Losses in Computers," CSLS Research Note 2010-01(Ottawa: Centre for the Study of Living Standards).

Shea, John (1998) "What Do Technology Shocks Do?" *NBER Macroeconomics Annual*, Vol. 13, pp. 275-310.

Stiroh, K. J. (2002) "Information Technology and the US Productivity Revival: What Do the Industry Data Say?" *American Economic Review*, Vol. 92, No. 5, pp. 1559-76.

Van Ark, B., Robert Inklaar and Robert H. McGuckin (2003) "The Contribution of ICT-Producing and ICT-Using Industries to Productivity Growth: A Comparison of Canada, Europe and the United States," I*nternational Productivity Monitor*, Number 6, Spring, pp. 56-63.

Appendix A
Sample Marc Record and Associated Online Display

Marc Record:

00992cam 2200253 a

4500001000800000005001700008008004100025035002100066906004500087010001700132020004600490400018001950500027002130820016002401000027002562450089002832600122003723000034004945000020005286500043005486500043005916300038006349910066006724768599-19930312102159.8-860214s1986 waua 001 0 eng - 9(DLC) 86002512- a7bcbccorignewd1eocipf19gy-gencatlg- a86002512 - a0914845705 (pbk.) :c$17.95 ($27.95 Can.)- aDLCcDLCdDLC-00aQA76.8.I2594bA541986-00a005.265219-1 aAndrews, Nancy,d1945--10aWindows :bthe official guide to Microsoft's operatingenvironment / cNancy Andrews.- aRedmond, Wash. :bMicrosoft Press ;a[New York] :bDistributed to the book trade in the U.S. by Harper & Row,cc1986.- axii, 292 p. :bill. ;c24 cm.- aIncludes index.- 0aIBM Personal Computer XTxProgramming.-0aIBM Personal Computer ATxProgramming.-00aMicrosoft Windows (Computer file)- bc-GenCollhQA76.8.I2594iA54 1986p00034791090tCopy 1wBOOKS

Online display of information in Marc Record:

Windows: the official guide to Microsoft's operating environment

4768599

LC control no.: 86002512

Type of material: Book (Print, Microform, Electronic, etc.) Personal name: Andrews, Nancy, 1945-

Main title: Windows : the official guide to Microsoft's operating environment / Nancy Andrews.

Published/Created: Redmond, Wash. : Microsoft Press ; [New York] : Distributed to the book trade in the U.S. by Harper & Row, c1986.

Description: xii, 292 p. : ill. ; 24 cm.

ISBN: 0914845705 (pbk.) : $17.95 ($27.95 Can.)

Notes: Includes index.

Subjects: Microsoft Windows (Computer file)

IBM Personal Computer XT --Programming.

IBM Personal Computer AT --Programming.

LC classification: QA76.8.I2594 A54 1986

Dewey class no.: 005.265

Appendix B
Computer Classifications in Library of Congress Classification and the Dewey Decimal System

In the Library of Congress, the books pertaining to Computers and Computer science are typically listed under the subclass QA Mathematics. For the indicators created in the paper, we used books classified under the QA 75 and QA 76 groups. Specifically, these are the books classified under QA75-76.95 Calculating machines which include titles on electronic computers, computer science, and computer software.

The indicators also include books classified under the Dewey Decimal System classifications 004 – 006. The items under these designations are grouped as follows:

004 Data processing & computer science

005 Computer programming, programs & data

006 Special computer methods

Why Aren't Workers Benefiting from Labour Productivity Growth in the United States?

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Kar-Fai Gee
Centre for the Study of Living Standards

ABSTRACT

Changes in real wages, or wages adjusted for the cost of living, are the most direct route through which labour productivity affects living standards. Yet labour productivity in the United States increased by 80 per cent between 1973 and 2011, while median real hourly wages remained virtually stagnant. This article presents a framework in which this reality is decomposed into four components: deterioration of labour's terms of trade, rising benefits as a share of wages, decline of the share of labour compensation in GDP, and rising wage inequality. Since 2000, the historically large gap between real median wages and productivity in the United States was driven by rising wage inequality and the decline of labour compensation as a share of GDP.

RÉSUMÉ

Les changements des salaires réels, ou des salaires corrigés du coût de la vie, sont la voie la plus directe de l'incidence de la productivité du travail sur les niveaux de vie. Pourtant, la productivité du travail a augmenté de 80 % aux États-Unis entre 1973 et 2011, pendant que le salaire horaire réel médian restait toutes fins utiles stagnant. Cet article présente un cadre dans lequel cette évolution est décomposée en quatre parties : la détérioration des termes d'échange des travailleurs, l'augmentation des bénéfices en pourcentage des salaires, la diminution de la part de la rémunération du travail dans le PIB et l'augmentation de l'inégalité salariale. Depuis 2000, l'écart entre les salaires réels médians et la productivité aux États-Unis vient de l'inégalité croissante des salaires et la diminution de la rémunération du travail en pourcentage du PIB.

CHANGES IN REAL WAGES, or wages adjusted for the cost of living, are the most direct route by which labour productivity affects living standards. Yet gains in the real median hourly wage in the United States have lagged far behind that of labour productivity. During the 1973 to 2011 period, the real median hourly wage increased 4.0 per cent, yet labour productivity rose 80.4 per cent. If the real median hourly wage had grown at the same rate as labour productivity over the period, it would have been $27.87 in 2011 (2011 dollars), considerably more than the actual $16.07 (2011 dollars). The objective of this article is to provide a comprehensive and

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consistent decomposition of the factors explaining the divergence between growth in real median wages and labour productivity since 1973 in the United States, with particular attention to the post-2000 period.

This article is divided into four sections. The first section briefly sets out the analytical framework used in the article and discusses measurement issues, while the second section reviews trends in the various components. The third section provides an accounting reconciliation of the gap between the growth rate of median real wages and labour productivity in the United States and discusses the drivers of this gap. The fourth section concludes.[2]

Analytical Framework and Definitions

At the aggregate level, when defined consistently, long-term growth in median real compensation is determined by labour productivity growth. This relationship is mediated by changes in labour's share of income, labour's terms of trade (the price of the output produced by workers relative to their cost of living), wage inequality (average compensation relative to median compensation), and the benefits ratio (compensation, or wages and benefits, divided by wages).[3]

(1) Labour Productivity Gap
= Δ Labour Productivity – Δ Real Median Hourly Wage
= – Δ Labour's Share – Δ Labour's Terms of Trade + Δ Wage Inequality + Δ Benefits Ratio

where Δ indicates a percentage change or the annual growth rate.[4]

- Nominal median hourly wage was calculated by the Economic Policy Institute (EPI) based on micro data from the Current Population Survey (CPS).[5]
- Nominal median hourly compensation was based on the median wage, adjusted for the average benefits ratio (total current dollar wages and benefits divided by total wages) taken from National Income and Product Account (NIPA) wages and benefits data from the Bureau of Economic Analysis (BEA).
- Nominal average hourly compensation was derived from total nominal labour compensation including an imputation for the labour income of the self-employed divided by total hours worked from unpublished BLS data.

All of these measures are for the total economy.

Real hourly wages are calculated by deflating nominal hourly wages by the CPI-U-RS. Nominal benefits are disaggregated into health

2 This article is based on a decomposition framework developed by the Centre for the Study of Living Standards (Sharpe *et al.*, 2008a; Sharpe *et al.*, 2008b; Harrison, 2009).

3 Or, more formally, $[Y/(P_Y \times H)]/[W_{med}/P_C]=[Y/(C_{ave} \times H)] \times (P_C/P_Y) \times (C_{ave}/C_{med}) \times (C_{med}/W_{med})$, where C_{ave} is the average nominal hourly compensation, P_Y is the GDP deflator, H is the total number of hours worked including self-employed, W_{med} is the nominal median wage, P_C is an implicit price index for consumers, P_Y is the GDP deflator, Y is nominal GDP, and C_{med} is the nominal median compensation which includes an imputation for the labour compensation of the self-employed. Therefore, $Y/(P_Y \times H)$ is labour productivity, W_{med}/P_C is real median hourly wage, $Y/(C_{ave} \times H)$ is labour's share of nominal GDP, P_C/P_Y is labour's terms of trade, C_{ave}/C_{med} is wage inequality, and C_{med}/W_{med} is the benefits ratio.

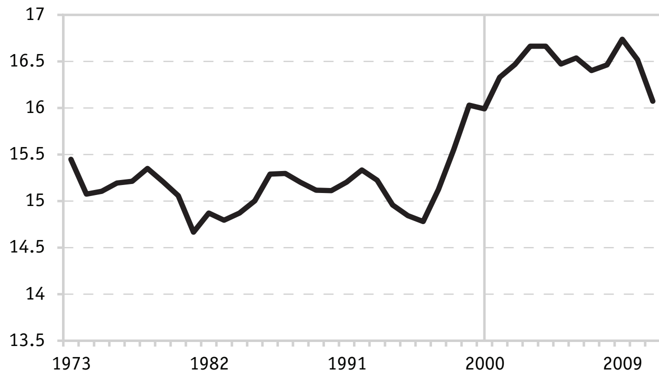
4 A similar methdology was followed in Pessoa and Van Reenan (2012). They define net decoupling as the divergence in growth rates between productivity and real average compensation where the GDP deflator is used to deflate both nominal GDP and nominal compensation. Gross decoupling is defined as the divergence in growth rates between productivity and real median wages where the GDP deflator is used to deflate nominal GDP and the Consumer Price Index is used to deflate nominal wages.

5 To be published in Mishel *et al*, 2012.

insurance and non-health insurance components, each of which is deflated using a different price index. The health insurance component of benefits is deflated by the price index for medical services used in the BEA Personal Consumption Expenditures (PCE) Index. All other benefits are deflated by the CPI-U-RS. Total compensation in real terms is the sum of the deflated wages, health insurance benefits and other benefits. An implicit price index for compensation can be calculated by dividing nominal compensation by real compensation. This implicit price index is hereafter referred to as the consumption price index or deflator.[6] Unless otherwise indicated, all real estimates are expressed in constant 2011 dollars.[7]

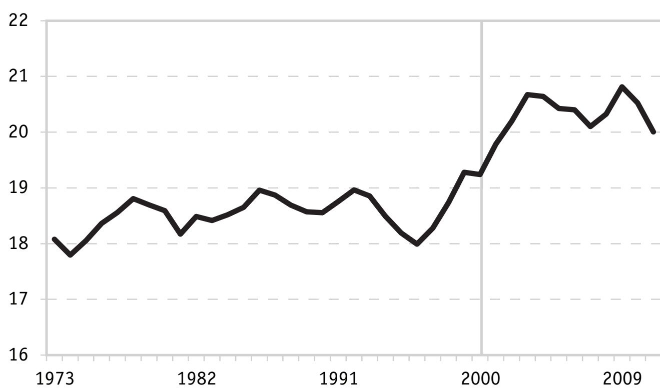
- Labour productivity is calculated by dividing real expenditure-based GDP, obtained from BEA NIPA tables, by the number of hours worked for all workers, including the self-employed, from unpublished BLS data.
- Labour's share of nominal GDP is total labour compensation divided by GDP. The former is calculated by multiplying average nominal hourly compensation by the number of hours worked, both from unpublished BLS data. The latter was obtained from BEA NIPA tables.
- Labour's terms of trade are calculated by dividing the index for the GDP deflator by the index for the consumption price index, the weighted average of the CPI-U-RS and

Chart 1
Real Median Hourly Wage, United States, 1973-2011
(constant 2011 dollars per hour)



Source: Analysis of CPS U.S. Census Bureau, Current Population Survey, Outgoing Rotations Group public-use micro data in Mishel *et al.* (2012).

Chart 2
Real Median Hourly Compensation, United States, 1973-2011
(constant 2011 dollars per hour)

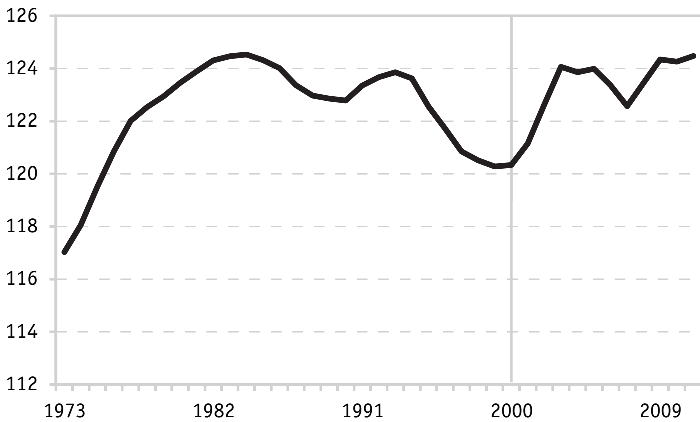


Source: Analysis of CPS U.S. Census Bureau, Current Population Survey, Outgoing Rotations Group public-use micro data and BEA NIPA tables in Mishel *et al.* (2012).

6 This index is a weighted average of the growth rates of the CPI-U-RS and the medical services price index from the PCE, with the weight for the latter the nominal value of health insurance in total compensation (2.6 per cent in 1973 and 7.2 per cent in 2010). The small weight means that the divergence in growth rates between the CPI-U-RS and the consumption price index is small, only 0.06 percentage points per year from 1973 to 2011 (4.13 per cent versus 4.19 per cent). The rate of increase for the price of medical benefits was however much faster than the CPI-U-RS: 5.86 per cent per year versus 4.13 per cent.

7 An alternative price index to the CPI-U-RS is the Personal Consumption Expenditure (PCE) deflator used in the GDP deflator. While the CPI-U-RS measures the change in prices for a market basket of consumer goods for an urban consumer, the BEA PCE index measures the prices of goods and services in the personal sector in the United States national income and product accounts. During the 1973 to 2011 period, the average annual growth rate for the PCE deflator was 3.87 per cent, 0.26 percentage points less than the 4.13 per cent rate of increase for the CPI-U-RS. Use of the PCE deflator series would consequently raise real wage growth by this amount each year over the 1973-2011 period. For more information on the methodological differences between the two price indexes, see McCully *et al.*, 2007.

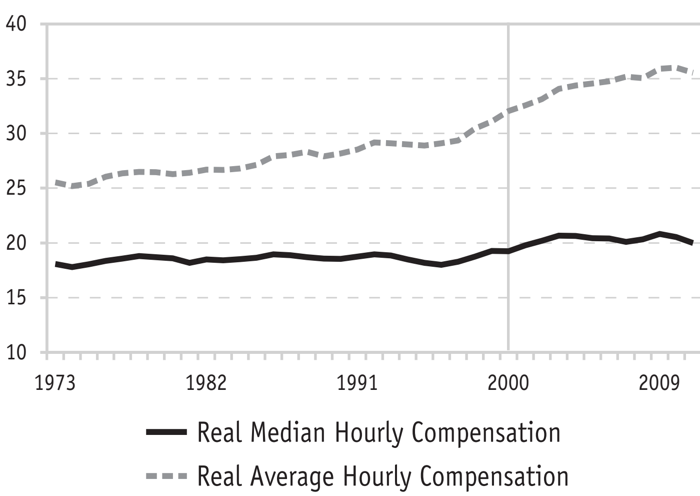
Chart 3
Benefits Ratio (Compensation/ Wages), United States, 1973-2011
(per cent)



Source: Analysis of CPS U.S. Census Bureau, Current Population Survey, Outgoing Rotations Group public-use micro data in Mishel *et al.* (2012).

Note: Calculated by dividing real compensation by real wage.

Chart 4: Average and Median Real Hourly Compensation, United States, 1973-2011
(constant 2011 dollars per hour)



Source: Real median hourly compensation from analysis of CPS U.S. Census Bureau, Current Population Survey, Outgoing Rotations Group public-use micro data in Mishel *et al.* (2012). Real average hourly compensation from unpublished BLS data.

the medical services price index from the PCE, with the weight for the latter equal to the share of the nominal value of health insurance in total compensation.

- Wage inequality is proxied by the ratio of average hourly compensation to median hourly compensation.
- The benefits ratio is the ratio of compensation (the sum of wages and benefits) to wages derived from BEA NIPA tables.

Trends in Wages and Productivity in the United States, 1973-2011

The framework outlined above provides the basis for decomposing the gap between labour productivity and real median hourly wages. This section will examine the trends in these two variables and the factors mediating the relationship between them over the 1973-2011 period.[8]

Real Median Hourly Wage

The real median hourly wage represents the wage of the worker at the mid-point of the wage distribution. This measure increased from \$15.45 per hour (2011 dollars) in 1973 to \$16.07 in 2011 for an average annual increase of 0.10 per cent per year (Chart 1). In absolute terms, this amounted to an increase of 62 cents over 38 years, or 1.6 cents per year. One notes that the rate of increase was not constant throughout the period. The real median wage fluctuated around \$15.00 from 1973 to 1997, at which point it began to increase sharply until 2003. Since then until 2010, it remained relatively stagnant at around \$16.50. In 2011, the real median hourly wage fell 2.7 per cent. Somewhat surprisingly, this stagnation in wages was evident among those with college degrees as well as those with high school degrees.

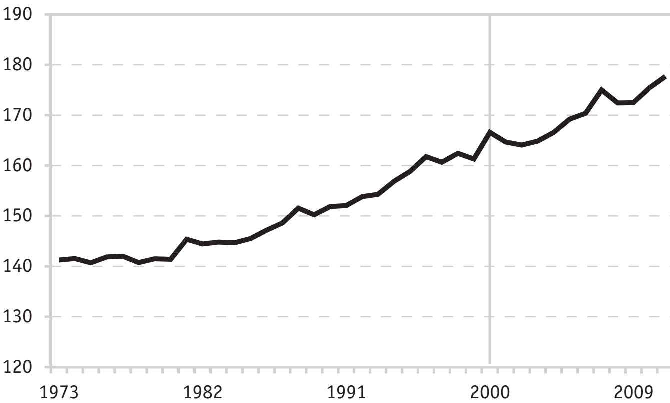
8 A set of tables containing the time series from 1973 to 2011 for all variables is posted with this article at http://www.csls.ca/ipm/23/appendix-mishel-gee.pdf.

Real Median Hourly Compensation

Real median hourly compensation includes total benefits as well as wages and salaries. Wages and salaries represent a much larger share of compensation than benefits, and so it is unsurprising that the real median compensation followed a similar pattern to the real median wage. Real median hourly compensation rose from $18.08 (2011 dollars) in 1973 to $20.01 in 2011, an average annual rate of increase of 0.27 per cent per year (Chart 2).[9] Real median compensation was stagnant between 1973 and 1996. It then rose significantly between 1996 and 2003 before again stagnating. It fell 2.5 per cent in 2011. Considering the two sub-periods, the real median compensation grew at 0.23 per cent per year from 1973 to 2000, and 0.35 per cent per year from 2000 to 2011.

The benefits ratio is defined as real median hourly compensation divided by real median wages. Chart 3 shows that the median real compensation was 17.0 per cent higher than the median real wage in 1973, with the gap rising to 24.5 per cent in 2011. All of this increase took place between 1973 and 1982 during which growth in real median compensation was much higher than the growth in the real median wage. Between 1982 and 2011, the rate of growth of the real median wage and median compensation has been, on average, the same.

Chart 5
Ratio between Average and Median Real Hourly Compensation, United States, 1973-2011
(per cent)



Source: Real median hourly compensation from analysis of CPS U.S. Census Bureau, Current Population Survey, Outgoing Rotations Group public-use micro data in Mishel *et al.* (2012). Real average hourly compensation from unpublished BLS nominal compensation and hours data.

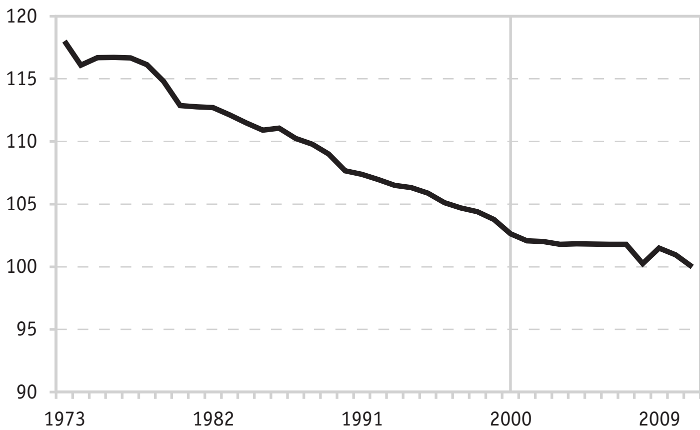
Note: Calculated by dividing average real compensation by median real compensation.

Real Average Hourly Compensation

Real average hourly labour compensation is calculated by dividing total real labour compensation by the total number of hours worked by all workers. Large increases in compensation at the top of the distribution can boost the average significantly. However, despite this increase in the average, most workers might not have seen an increase in compensation. The median, which represents the compensation of the person at the midpoint of the distribution, is generally not affected by changes at only the top or bottom of the distribution. Therefore, average

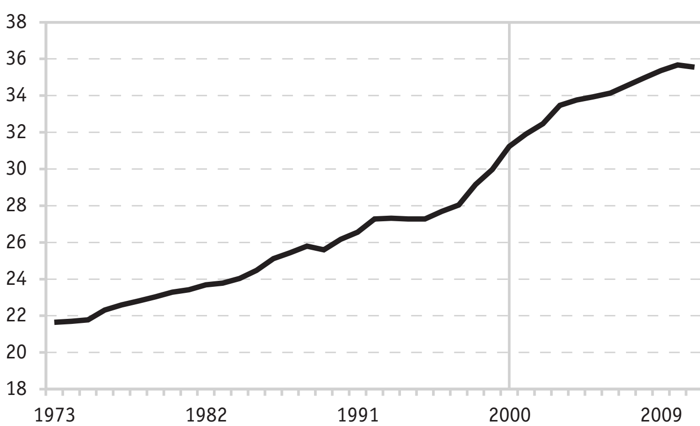
9 Compensation is partitioned into two categories: wages and salaries, and total benefits. Total benefits, which include social insurance, health insurance, and pensions, has increased from 12.6 per cent of total compensation in 1973 to 19.6 per cent in 2010 in nominal terms (BEA NIPA table 6.11). In real terms, with health insurance deflated with a medical deflator and the remaining portions of compensation deflated by the CPI-U-RS the benefits share rose from 14.6 per cent of total compensation in 1973 to 18.7 per cent in 1979 but grew only to 19.5 per cent by 2010. This is consistent with the trend observed here of compensation increasing somewhat faster than wages.

Chart 6
Labour's Terms of Trade, United States, 1973-2011
(index 2011 = 100)



Source: BEA NIPA tables.
Note: Calculated by dividing the GDP deflator by the consumption price index.

Chart 7
Real Average Product Compensation, United States, 1973-2011
(constant 2011 dollars)



Source: BEA NIPA tables and unpublished BLS data.

compensation that rises faster than median compensation is indicative of growing inequality.[10]

Real average hourly compensation has increased from $25.54 (2011 dollars) in 1973 to $32.05 in 2000, and further rose to $35.55 in 2011, which represents an annual growth rate of 0.87 per cent per year over the whole period (Chart 4).[11] The growth rate was almost identical in both the 1973-2000 sub-period (0.84 per cent per year) and in the 2000-2011 sub-period (0.95 per cent per year). This was considerably faster than the growth in median compensation over the same period. Moreover, the ratio between the average and median real compensation has increased in an almost linear fashion over that period indicating a continuous growth of wage inequality. Real average hourly compensation was 41.3 per cent higher than the median real hourly compensation in 1973, and the gap increased to 77.7 per cent in 2011 (Chart 5).

Real Average Product Compensation

The real average product compensation or producer wage differs from the real average consumer compensation, or consumer wage, by its use of the GDP deflator rather than the consumption price index or deflator. Therefore, the ratio between the real average product compensation and the real average consumer compensation is the ratio between the GDP deflator and the consumption price index or deflator. The relationship between these two price indexes is often called labour's terms of trade. There are two ways that this divergence in prices can be viewed. One way is

10 Mathematically speaking, there is no necessary relationship between trends in wage inequality and the ratio between average compensation and median compensation. One could imagine where wage inequality increases but the median increases more than the average. For example, if the wages of workers in the 20-40th percentile of the wage distribution fell to the wage of those at the 10th percentile, the average wage would decrease, but the median would stay the same. However, wage inequality would increase. This example does not currently apply to the United States, as it is well know that wage inequality is rising due to increased wages at the top half of the distribution.

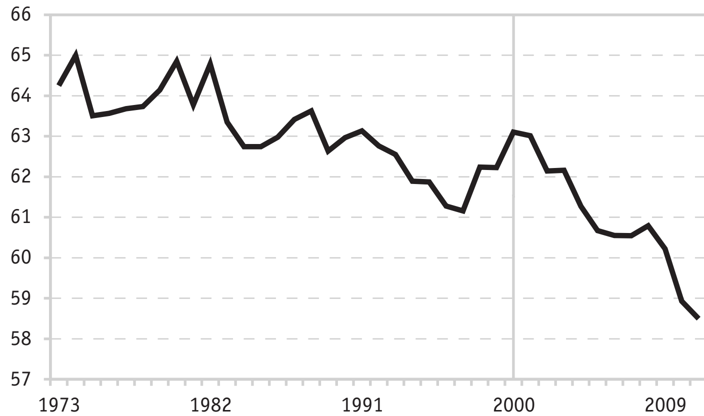
11 This measure of nominal average compensation rose by 3.63 per cent per year from 2000 to 2010. There are a number of other wage measures outlined in the *Economic Report of the President 2012* (United States Government, 2012). Over the same period, total compensation according to the Employer Costs of Employee Compensation rose by 3.01 per cent per year (Appendix Table B-47), while the nominal compensation per hour in the business sector rose by 3.47 per cent per year (Appendix Table B-49).

to dismiss the divergence as a technical difference and to treat the resulting productivity – compensation gap as unimportant and uninteresting. The second view is to note that the assumption that gains in labour productivity translate into improvements in living standards implies that these two deflators must converge in the long run. Given that this convergence has not occurred for several decades, the second view suggests that productivity is not translating fully into improved living standards and the divergence between the consumption deflator and GDP deserves serious inquiry.

As seen in Chart 6, between 1973 and 2011, the ratio between the consumption price deflator and GDP deflator has steadily decreased by 0.44 per cent per year, reflecting the faster growth in the consumption price index relative to the GDP deflator (4.19 per cent versus 3.73 per cent per year). In other words, that the prices of consumer items has risen faster than a broader index of prices that includes net exports, government goods and services, and investment goods. Therefore, for a given increase in income, the purchasing power of the consumer has fallen faster than that of business for investment goods and foreigners for U.S. exports. The deflator for private investment rose only 2.81 per cent per year from 1973 to 2011 as the price index for equipment and software only rose 1.17 per cent per year, given the absolute decline in the prices for ICT investment goods (BEA NIPA Table 1.1.4).

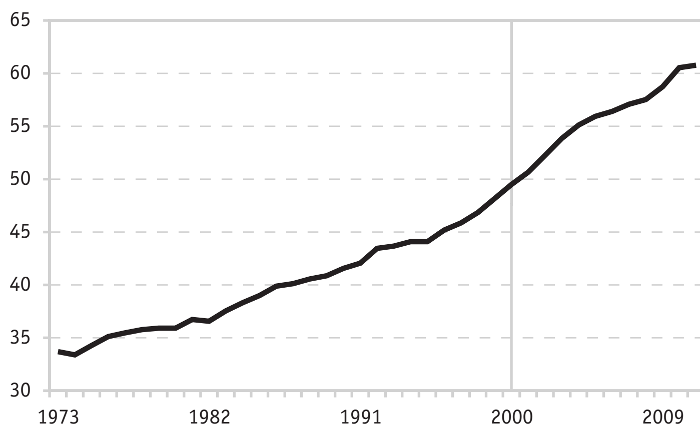
Given these developments, real average product compensation rose at a 0.44 per cent faster rate between 1973 and 2011, than real average consumer compensation from $21.64 (2011 dollars) in 1973 to $35.55 in 2011 or 1.31 per cent per year (Chart 7). The growth rate of the real average product compensation was slightly faster during the 1973-2000 (1.31 per cent per year) sub-period than during the 2000-2011 (1.18 per cent per year) sub-period.

Chart 8
Labour's Share of Nominal GDP, United States, Total Compensation as a Share of GDP, 1973-2011
(current dollars, per cent)



Source: BEA NIPA tables.

Chart 9
Labour Productivity, United States, 1973-2011
(2011 constant dollars per hour)

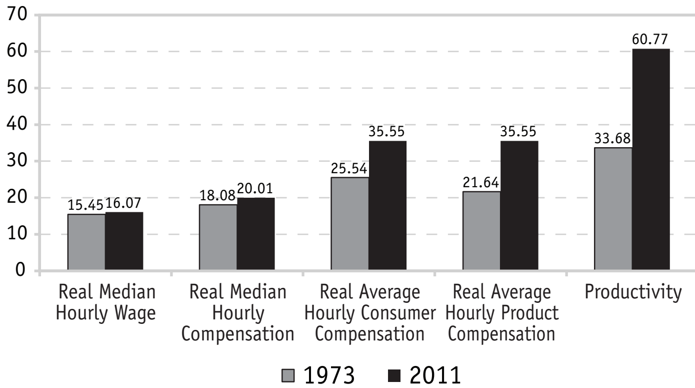


Source: GDP data from BEA and total number of hours worked from unpublished data from BLS.

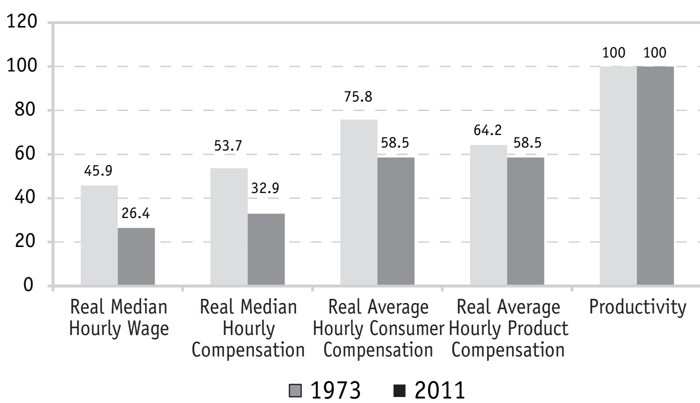
Labour's Share of Nominal GDP

The labour share, defined as the share of total nominal compensation in nominal GDP,[12] fell from 64.3 per cent to 58.5 per cent of GDP between 1973 and 2011 (Chart 8). The labour

Chart 10
Comparison of Wage, Compensation, and Productivity Measures, United States, 1973 and 2011
(constant 2011 dollars)



(proportion of productivity, per cent)



Source: EPI, BLS and BEA data.

share fell from 1973 to the mid-1990s and then rebounded during the robust growth of the second half of the 1990s. Between the business cycle peaks of 1973 and 2000 the labour share fell only 1.1 percentage points. On the other hand, the fall between 2000 and 2011 was much more drastic, as it decreased 4.6 percentage points from 63.1 per cent to 58.5 per cent of GDP.

Labour Productivity

Labour productivity is the output produced per hour by the average worker, including the self-employed, and is measured in terms of real GDP per hour worked. Labour productivity was $33.68 (2011 dollars) in 1973 and grew an average of 1.56 per cent per year to $60.77 in 2011 (Chart 9). Labour productivity growth has been steadily increasing, as it grew by 1.44 per cent per year from 1973 to 2000, and 1.88 per cent per year between 2000 and 2011.

Comparison of Wage, Compensation and Productivity Measures

Given the different growth rates of real median wages and productivity as well as the factors mediating between the relationship between these two variables, median wages as a proportion of labour productivity has greatly fallen in the last four decades. In 1973, the real median hour wage in the United States was 45.9 per cent of output per hour (Chart 10). By 2011, this proportion had fallen to 26.4 per cent. In other words, the wage of the median worker used to account for slightly less than one half of average productivity. Now it is just slightly above one quarter. [13]

An Accounting Perspective on the Gap between Median Real Wage Growth and Labour Productivity Growth

The real hourly median wage of workers in the economy has increased only 4.0 per cent (0.1 per cent per year) from $15.45 (2011 dollars) in 1973 to $16.07 (2011 dollars) in 2011, or less than two cents a year. Over the same period, total economy labour productivity rose 80.4 per

12 This measure of labour's share is not the preferred metric to examine whether there is a redistribution of income from labour to capital. This is because changing shares of the government/non-profit sector (which have only labour compensation) and the proprietor's sector in the national economy affects this ratio. To examine such labor-capital redistribution requires examining labour's share in the corporate sector.

13 The two measures of average compensation in Chart 10 differ only in their use of deflator. The use of 2011 as the index year for both means that real average compensation will be the same in 2011. However, the average product compensation was lower than the average consumer compensation in 1973.

Table 1
Reconciling Growth in Median Real Wages and Labour Productivity in the United States, 1973-2011 and Selected Sub-Periods

	1973-1979	1979-1995	1995-2000	2000-2011	1973-2011
Productivity-median wage growth gap	**Compound Annual Growth Rate**				
Median real hourly wage	-0.26	-0.15	1.50	0.05	0.10
Labour productivity (Real output per hour)	1.08	1.29	2.33	1.88	1.56
Total productivity-median wage gap	1.34	1.44	0.84	1.84	1.46
Contribution to productivity-median wage gap	**Absolute Contribution (percentage points)**				
From median real hourly wage to median real hourly compensation	0.82	-0.02	-0.37	0.31	0.16
From median real hourly compensation to average real hourly compensation	0.02	0.72	0.96	0.59	0.61
From consumption price index to GDP deflator	0.46	0.51	0.63	0.24	0.44
Changes in labour share of nominal GDP	0.03	0.23	-0.39	0.69	0.25
Total - all factors	1.34	1.44	0.83	1.82	1.45
	Relative Contribution (per cent of gap)				
From median real hourly wage to median real hourly compensation	61.6	-1.4	-43.6	16.8	11.1
From median real hourly compensation to average real hourly compensation	1.9	50.3	114.9	32.0	41.4
From consumption price index to GDP deflator	34.4	35.2	74.8	12.9	29.9
Changes in labour share of nominal GDP	2.1	15.6	-47.0	37.6	16.9
Total - all factors	100.0	100.0	100.0	100.0	100.0

Source: calculations based on BLS, BEA and EPI data. Figures may not sum exactly due to rounding.

cent, or on average, 1.56 per cent per year. Therefore, on average, workers have benefitted very little from growth in labour productivity in terms of real wage growth. As discussed earlier, a number of factors mediate the relationship between labour productivity and median wage growth. Table 1 provides a decomposition to account for the growing disconnect between the median real wage and labour productivity growth for the 1973-2011 period and four sub-periods (1973-79, 1979-1995, 1995-2000, and 2000-2011).

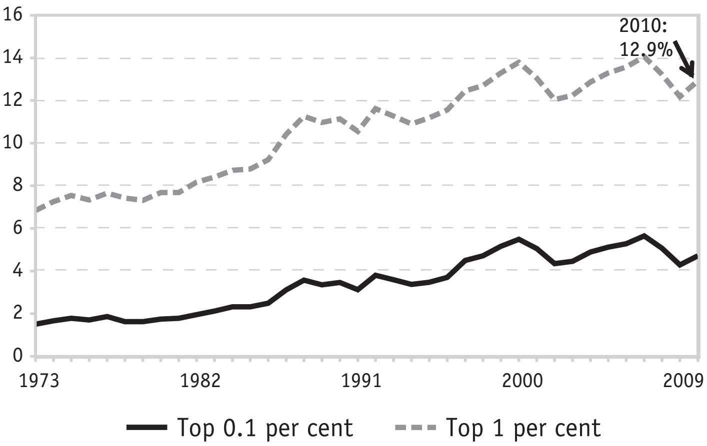
Over the total 1973-2011 period, the gap between median wage and productivity growth was 1.46 percentage points per year. The gap varied between sub-periods, from a low of 0.84 percentage points per year in 1995-2000 to a high of 1.84 percentage points in 2000-2011.

For the total 1973-2011 period, the most important factor accounting for the divergence in median wage and productivity growth was growing wage inequality, responsible for 0.61 percentage points or 41.4 per cent of the gap. The second most important factor was the declining terms of trade of labour (that is, faster growth of the consumption price index than the GDP deflator), accounting for 0.44 percentage points or 29.9 per cent. The falling share of labour compensation in GDP was responsible for 0.25 percentage points

Chart 11

Top 1 per cent and 0.1 per cent Share of Total Wages and Salaries, United States, 1947-2010

(per cent of all wages and salaries)

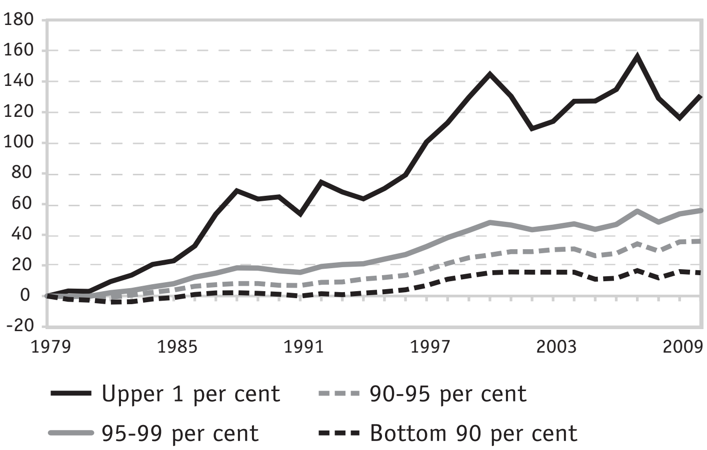


Source: Mishel *et al.* (2012).

Chart 12

Wage Growth by Wage Group, United States, 1979-2010

(per cent change from 1979 level)



Source: Mishel *et al.* (2012).

or 16.9 per cent of the gap and the rising benefits ratio 0.16 percentage points or 11.1 per cent.

The contributions to the gap, both in absolute and relative terms, varied by sub-period.[14] During the most recent 2000-2011 period, the most important factor was the declining share of labour, which accounted for 0.69 percentage points or 37.6 per cent of the gap. Rising wage inequality was second in importance at 0.59 points or 32.0 per cent of the gap.

One particularly interesting sub-period is 1995-2000 when real median wages grew by an average of 1.50 per cent per year. Since productivity growth was at its peak during that sub-period (2.33 per cent), the productivity-median wage gap did not disappear, but did fall considerably. However, the rate of growth of wage inequality was particularly strong during his sub-period (0.96 percentage points), although this development was partially offset by a rise in labour's share (-0.39 percentage points contribution to the gap). This was a period of strong economic growth and falling unemployment, showing that a strong economy can at least offset, if not reverse, what appears to be a secular or long-run tendency for real median wages to underperform productivity growth.[15]

The remainder of this section will examine the two most important drivers of the gap between 2000 and 2011: growing earnings inequality and labour's falling share of GDP.

Wage inequality

As noted earlier, average real hourly compensation has been increasing more rapidly

14 Relative contributions are of course sensitive to the absolute size of the gap. The absolute contribution of a factor may remain unchanged between periods, but the relative contribution can change dramatically if the size of the gap changes.

15 A similar decomposition framework was used by Pessoa and Van Reenan (2012), who also found that a major gap developed between productivity and real median wages in the United States over the 1975-2010 period. They attribute about two-fifths of the gap to the faster growth in consumer prices relative to the GDP deflator and one-fifth each to growing wage inequality, growing benefits as a share of wages, and faster growth in productivity relative to average compensation deflated by the GDP deflator (which they label net decoupling). The key difference between the two studies is the larger relative importance given to rising wage inequality in accounting for the gap in this study: 40 per cent versus 20 per cent.

than the median real compensation for the period 1973 to 2011, as well as during each of the sub-periods chosen. This growing wage inequality has been driven by more rapid wages or earnings growth at the top of the distribution. In particular, household income at the upper limit of the first quintile saw compound annual growth rates of 1.22 per cent from 2000 to 2010, while household income at the lower limit of the top 5 per cent increased by 2.22 per cent per year. Using Social Security Administration wage data from Kopczuk, Saez and Song (2007) updated by published wage data we can examine wage trends at the very top of the wage structure.[16]

Chart 11 illustrates that the share of all wages accounted for by the top 1 per cent of wage earners has nearly doubled, from 6.8 per cent in 1973 to 12.9 per cent in 2010. This effect is even more pronounced in the top 0.1 per cent of wage earners, as their share of wages has tripled from 1.5 per cent in 1979 to 4.7 per cent in 2010. This is partially due to rising wages at the top of the income distribution, as the earnings of the bottom 90 per cent of wage earners in 2010 were 115 per cent of their 1979 wage (Chart 12). In contrast, wages have increased much more for the top 1 per cent of earners (230.9 per cent of their 1979 wage). The issue of income inequality has come to the forefront of national consciousness with the rise of various social movements, such as Occupy Wall Street.

These data show the substantial gaps that have emerged between the earnings of the top 1 percent of earners and other high earners within the upper 10 percent. Other dimensions of wage inequality have grown over the last thirty years (Mishel *et al.*, 2012 for further analysis). For instance, there has been a continuing gap between the growth of wages at the 90th and 95th percentiles and the median wage over the entire 1979-2011 period. A third dimension of wage inequality—the gap between the middle and the bottom (the 50/10 wage gap)-- has emerged in some sub-periods but not in others: the gap grew strongly in the 1980s but remained flat in the 1990s and the 2000s, except for a re-emerging gap among men in the last few years. Any explanation or explanations of wage inequality has to account for this pattern of wage growth.

Labour's share of nominal GDP

As noted earlier, labour's share of nominal GDP fell from 64.2 per cent in 1973 to 58.5 per cent in 2011. It should be noted that with the large labour compensation increases of top earners (which include realized stock options granted to top corporate officers), the labour share of the bottom end of the distribution fell even more than what is represented by total figures.

In addition, as noted earlier, labour's share of nominal GDP is not an accurate measure of the distribution of income between capital and labour because it includes the proprietor's sector (where the types of income are not easily discerned) and the government/non-profit sector (which has only wage income). Analysis of profitability and the division of income between labour and capital have usefully focused on the corporate sector and a recent analysis shows that capital's share of income in 2010, and generally in the 2000s, has been historically high. Specifically, capital's share of corporate sector income in 2010 was 26.2 per cent, far above the average share over the 1960-2007 period of 20.5 per cent. In fact, capital's share of income in 2010 was "the highest share since the years during World War II, when national policy used wage and price controls to consciously suppress wage growth" (Mishel and Shierholz, 2011: 23).

16 See Mishel *et al*. (2012) for details.

Factors Driving Increased Wage Inequality and the Falling Labour Share of National Income

It goes beyond the scope of this article to provide a comprehensive explanation of the complex and interrelated factors behind growing wage inequalities and the redistribution of income from labour to capital. The ratcheting up of capital's share of income in the 2000s occurred at the same time as weak growth of both college-educated and high school-educated workers' wages, suggesting that the same set of factors might be at work. In this light, the historic weakness of trade unions and the erosion of labour standards—from low minimum wages, weaker overtime provisions, eroded prevailing wage standards and weak enforcement of labour standards—play a significant role. Increased globalization (and exposure to low wage imports, most prominently from China) and high trade deficits also put increased downward pressure on wages. Moreover, the relatively weak recovery of the 2002-07 period and the high unemployment in the great recession has meant that the low unemployment that enabled workers to make great wage gains in the late 1990s was unavailable in recent years.

There is much discussion of skill-biased technical change as a cause of growing wage inequality. It is hard, however, to find the winners from technical change in the last ten years, as the wages of the bottom 70 per cent of college graduates have been flat or in decline. That would leave just 30 per cent of college graduates (6.6 per cent of the workforce) and the 11 per cent of workers with advanced degrees as the winners of technical change. It also seems unlikely that technical change has generated the upward trajectory of the top 1 per cent of wage earners.

Lastly, one contributing factor to the gap between compensation and productivity growth has been the increase in the share of GDP accounted by the consumption of fixed capital. In recent years, the proportion of short-lived capital assets, such as information and communication technologies, has increased significantly as a share of new investment. Because these assets depreciate at a faster rate than other types of capital assets, a larger share of current production must be used to replace them. As a result, the share of consumption of fixed capital in GDI increased by 1.2 percentage points between 2000 and 2010. Much of this was due to the private sector, where the share of consumption of fixed capital in GDI increased by 0.8 percentage points.

Conclusion

The median real hourly wage in the United States has been basically stagnant between 1973 and 2011.[17] In contrast, labour productivity increased by 80 per cent. The purpose of this article has been to present a framework in which the gap between the median real hourly wage and productivity is decomposed into four main factors. In order of their relative importance in

17 Sharpe, Arsenault and Harrison (2008) also identified the emergence of a major gap in the growth of real median earnings and productivity in Canada between 1980 and 2005: 1.26 percentage points per year compared to 1.46 percentage points in the United States for the 1973-2011 period. The decomposition of this gap is similar, but not identical, betwen the two countries. The faster growth in consumer prices relative to the GDP deflator accounted for about one-third of the gap, and the falling share of labour income represented one-fifth of the gap in both countries. In contrast, growing wage inequality accounted for 28 per cent of the gap in Canada versus 42 per cent in the United States, while the growing benefits ratio was responsible for 28 per cent of the gap in Canada, versus only 11 per cent in the United States.

As was found for the United States and Canada, Pessoa and Van Reenan (2012) show that in the United Kingdom, real median wage growth also significantly lagged labour productivity growth between 1975 and 2010. The report found that the magnitude of the growth in the gap was two-thirds that experienced in the United States. About two-fifths of the increasing divergence between real median wages and labour productivity in the United Kingdom was due to rising wage inequality, one-third due to the growing benefits ratio, and one-quarter to the fall in labour's share of national income.

explaining the productivity-median wage gap from 1973 to 2011, they are: rising wage inequality (42.3 per cent of the gap), deterioration of labour's terms of trade (29.9 per cent of the gap), decline of labour compensation in GDP (16.9 per cent of the gap), and rising benefits as a share of wages (10.3 per cent of the gap).

Evidence of growing wage inequality can be found in the large compensation increases at the top of the income distribution, compared to the rest of earners. This can be observed from various dimensions. For example, the wages and salaries of the top 1 per cent of earners, as a share of all wages and salaries, has nearly doubled from 1973 to 2010. The effect is even more pronounced for the top 0.1 per cent of earners, as their share of all wages and salaries has tripled over the same period. In general, the lower the wage, the less it grew between 1973 and 2010.

Some of the reasons behind the rise in wage inequality and the redistribution of income from labour to capital were briefly mentioned in this article, though there is evidence that the same set of factors may influence both of them. These factors include the erosion of labour standards, increase in globalization, high trade deficits, as well as the rising share of capital depreciation in GDP. It is important to understand these trends and their impact on the productivity-median wage gap. Reducing this gap is of the utmost importance in order to ensure that labour productivity gains also translate into better living standards for most Americans.

References

Harrison, Peter (2009) "Median Wages and Productivity Growth in Canada and the United States," CSLS Research Report 2009-2, July.

Kopczuk, W., E. Saez, and J. Song (2007) "Uncovering the American Dream: Inequality and Mobility in Social Security Earnings Data since 1937," NBER Working Paper No. 13345, August.

McCully, C., B. Moyer and K. Stewart (2007) "A Reconciliation between the Consumer Price Index and the Personal Consumption Expenditures Price Index," Bureau of Economic Analysis and Bureau of Labor Statistics, September.

Mishel, L., and H. Shierholz (2011) "Sustained, High Joblessness Causes Lasting Damage to Wages, Benefits, Income, and Wealth," Economic Policy Institute, Briefing Paper No. 324. August 31.

Mishel, L., J. Bivens, E. Gould, and H. Shierholz (2012) *The State of Working America, 2012/2013*, Economic Policy Institute. (Ithaca, N.Y.: Cornell University Press), forthcoming.

Pessoa, J.P. and J.V. Reenen (2012) "Decoupling of Wage Growth and Productivity Growth? Myth and Reality," Resolution Foundation. http://www.livingstandards.org/wp-content/uploads/2012/02/Decoupling-of-wages-and-productivity.pdf

Sharpe, A., J. Arsenault, and P. Harrison (2008a) "Why Have Real Wages Lagged Labour Productivity Growth in Canada?" *International Productivity Monitor*, No. 17, Fall, pp. 17-26.

Sharpe, A., J. Arsenault and P. Harrison (2008b) "The Relationship between Productivity and Real Wage Growth in Canada and OECD Countries: 1961-2006," CSLS Research Report 2008-8, December.

United States Government (2012) *Economic Report of the President*, Transmitted to the Congress February 2012.

Appendix Table 1: Reconciling the Gap Between Real Median Hourly Wage and Labour Productivity, United States, 1973-2011

	Real Consumer Wage			Real average product compensation	Labour's share of GDP	Real GDP per hour worked
	Real median hourly wage	Real median hourly compensation	Real average hourly compensation			
	constant 2011 dollars	constant 2011 dollars per hour	constant 2011 dollars per hour	constant 2011 dollars per hour	per cent	constant 2011 dollars per hour
	[1]	[2]	[3]	[4]	[5]	[6]
1973	15.45	18.08	25.54	21.64	64.25	33.68
1974	15.07	17.80	25.19	21.70	64.99	33.39
1975	15.11	18.05	25.41	21.77	63.50	34.29
1976	15.19	18.36	26.05	22.32	63.57	35.11
1977	15.21	18.56	26.36	22.59	63.68	35.48
1978	15.35	18.81	26.48	22.80	63.73	35.78
1979	15.21	18.70	26.45	23.04	64.14	35.92
1980	15.06	18.59	26.29	23.29	64.85	35.91
1981	14.67	18.17	26.41	23.42	63.78	36.73
1982	14.87	18.49	26.70	23.69	64.79	36.56
1983	14.79	18.41	26.66	23.78	63.35	37.54
1984	14.87	18.52	26.79	24.04	62.74	38.31
1985	15.00	18.65	27.14	24.47	62.74	39.00
1986	15.29	18.96	27.90	25.12	62.97	39.88
1987	15.30	18.87	28.04	25.44	63.41	40.12
1988	15.20	18.69	28.33	25.80	63.63	40.55
1989	15.12	18.57	27.90	25.60	62.64	40.87
1990	15.11	18.55	28.18	26.17	62.97	41.56
1991	15.20	18.75	28.52	26.56	63.13	42.06
1992	15.33	18.96	29.17	27.27	62.76	43.46
1993	15.22	18.86	29.10	27.32	62.55	43.68
1994	14.96	18.49	29.00	27.28	61.89	44.08
1995	14.84	18.19	28.89	27.28	61.87	44.10
1996	14.78	17.99	29.10	27.69	61.28	45.19
1997	15.12	18.28	29.36	28.04	61.16	45.85
1998	15.55	18.74	30.44	29.15	62.24	46.84
1999	16.03	19.28	31.10	29.97	62.23	48.16
2000	15.99	19.24	32.05	31.23	63.10	49.49
2001	16.33	19.78	32.57	31.91	63.01	50.64
2002	16.47	20.19	33.12	32.47	62.14	52.25
2003	16.66	20.67	34.07	33.47	62.16	53.85
2004	16.66	20.64	34.38	33.76	61.27	55.10
2005	16.47	20.42	34.55	33.93	60.67	55.93
2006	16.54	20.40	34.75	34.14	60.55	56.39
2007	16.40	20.10	35.17	34.55	60.54	57.07
2008	16.46	20.33	35.05	34.96	60.79	57.51
2009	16.74	20.81	35.90	35.37	60.22	58.73
2010	16.52	20.53	36.00	35.67	58.93	60.53
2011	16.07	20.01	35.55	35.55	58.50	60.77
CAGR						
1973-11	**0.10**	**0.27**	**0.87**	**1.31**	**-0.25**	**1.56**
1973-81	-0.65	0.06	0.42	0.99	-0.09	1.09
1981-89	0.38	0.27	0.69	1.12	-0.22	1.34
1989-00	0.51	0.32	1.27	1.82	0.07	1.76
2000-07	0.36	0.63	1.33	1.45	-0.59	2.06
2007-11	-0.50	-0.12	0.27	0.71	-0.86	1.58
1973-00	**0.13**	**0.23**	**0.84**	**1.37**	**-0.07**	**1.44**
2000-11	**0.05**	**0.35**	**0.95**	**1.18**	**-0.69**	**1.88**
1973-79	-0.26	0.56	0.59	1.05	-0.03	1.08
1979-89	-0.06	-0.07	0.54	1.06	-0.24	1.30
1979-11	0.17	0.21	0.93	1.36	-0.29	1.66
1995-00	1.50	1.13	2.10	2.74	0.40	2.33
1995-11	0.50	0.60	1.30	1.67	-0.35	2.02

Sources

[1] Unpublishe data from the Economic Policy Institute from CPS microdata.
[2] Unpublished data from the Economic Policy Institute from CPS microdata.
[3] Appendix Table 2.
[4] Appendix Tables 2 and 3.
[5] Appendix Table 2.
[6] Appendix Table 2.

Note

All data reflects the whole economy.

Appendix Table 2: Labour Productivity and Real Wages, United States, 1960-2011

	Hours worked for all jobs	Average nominal hourly compensation for all jobs	Total nominal ompensation	Real average hourly compensation	GDP		GDP per hour worked	Labour share of GDP	Labour's terms of trade using the implicit price index (GDP / implicit price index)
	billions of hours	current dollars per hour	billions of current dollars	chained 2011 dollars per hour	billions of current dollars	billions of chained 2011 dollars	chained 2011 dollars	per cent	per cent
	[1]	[2]	[3]=[2]*[1]	[4]	[5]	[6]	[7]=[6]/[1]	[8]=[5]/[3]*100	[9]
1973	165.24	5.37	888.10	25.54	1,382	5,566	33.68	64.25	118.01
1974	165.84	5.88	974.55	25.19	1,500	5,537	33.39	64.99	116.09
1975	161.09	6.46	1,040.01	25.41	1,638	5,523	34.29	63.50	116.68
1976	165.76	7.00	1,159.84	26.05	1,825	5,820	35.11	63.57	116.71
1977	171.59	7.53	1,292.71	26.36	2,030	6,088	35.48	63.68	116.66
1978	179.66	8.14	1,461.91	26.48	2,294	6,428	35.78	63.73	116.12
1979	184.52	8.91	1,643.38	26.45	2,562	6,628	35.92	64.14	114.81
1980	184.01	9.83	1,808.08	26.29	2,788	6,609	35.91	64.85	112.87
1981	184.39	10.81	1,994.12	26.41	3,127	6,773	36.73	63.78	112.77
1982	181.65	11.60	2,107.63	26.70	3,253	6,642	36.56	64.79	112.71
1983	184.91	12.11	2,239.02	26.66	3,535	6,942	37.54	63.35	112.12
1984	194.24	12.70	2,466.30	26.79	3,931	7,441	38.31	62.74	111.48
1985	198.68	13.32	2,646.19	27.14	4,218	7,749	39.00	62.74	110.91
1986	201.01	13.97	2,808.73	27.90	4,460	8,017	39.88	62.97	111.07
1987	206.45	14.55	3,003.57	28.04	4,736	8,282	40.12	63.41	110.24
1988	212.62	15.26	3,245.17	28.33	5,100	8,622	40.55	63.63	109.78
1989	218.49	15.72	3,433.83	27.90	5,482	8,930	40.87	62.64	108.99
1990	218.87	16.69	3,652.35	28.18	5,801	9,096	41.56	62.97	107.67
1991	215.77	17.53	3,782.89	28.52	5,992	9,076	42.06	63.13	107.39
1992	215.95	18.43	3,980.47	29.17	6,342	9,384	43.46	62.76	106.96
1993	221.00	18.87	4,170.57	29.10	6,667	9,653	43.68	62.55	106.50
1994	227.92	19.24	4,384.86	29.00	7,085	10,046	44.08	61.89	106.33
1995	233.53	19.64	4,587.39	28.89	7,415	10,298	44.10	61.87	105.89
1996	236.45	20.31	4,803.31	29.10	7,839	10,684	45.19	61.28	105.11
1997	243.37	20.94	5,095.71	29.36	8,332	11,159	45.85	61.16	104.70
1998	248.61	22.01	5,472.91	30.44	8,794	11,646	46.84	62.24	104.40
1999	253.47	22.96	5,820.43	31.10	9,354	12,208	48.16	62.23	103.78
2000	256.85	24.45	6,279.48	32.05	9,952	12,712	49.49	63.10	102.63
2001	253.71	25.55	6,481.78	32.57	10,286	12,849	50.64	63.01	102.07
2002	250.41	26.41	6,613.24	33.12	10,642	13,083	52.25	62.14	102.01
2003	249.11	27.80	6,925.72	34.07	11,142	13,415	53.85	62.16	101.79
2004	251.91	28.83	7,262.64	34.38	11,853	13,881	55.10	61.27	101.83
2005	255.79	29.94	7,658.28	34.55	12,623	14,307	55.93	60.67	101.82
2006	260.46	31.10	8,100.21	34.75	13,377	14,686	56.39	60.55	101.79
2007	262.27	32.38	8,493.27	35.17	14,029	14,967	57.07	60.54	101.79
2008	259.44	33.49	8,687.50	35.05	14,292	14,920	57.51	60.79	100.26
2009	245.16	34.24	8,394.30	35.90	13,939	14,397	58.73	60.22	101.50
2010	245.06	34.93	8,559.92	36.00	14,527	14,833	60.53	58.93	100.95
2011	248.39	35.55	8,829.67	35.55	15,094	15,094	60.77	58.50	100.00
CAGR									
1973-11	**1.08**	**5.10**	**6.23**	**0.87**	**6.49**	**2.66**	**1.56**	**-0.25**	**-0.43**
1973-81	1.38	9.13	10.64	0.42	10.74	2.48	1.09	-0.09	-0.57
1981-89	2.14	4.78	7.03	0.69	7.27	3.52	1.34	-0.22	-0.42
1989-00	1.48	4.10	5.64	1.27	5.57	3.26	1.76	0.07	-0.55
2000-07	0.30	4.10	4.41	1.33	5.03	2.36	2.06	-0.59	-0.12
2007-11	-1.35	2.36	0.98	0.27	1.85	0.21	1.58	-0.86	-0.44
1973-00	**1.65**	**5.77**	**7.51**	**0.84**	**7.58**	**3.11**	**1.44**	**-0.07**	**-0.52**
2000-11	**-0.30**	**3.46**	**3.15**	**0.95**	**3.86**	**1.57**	**1.88**	**-0.69**	**-0.24**
1973-79	1.86	8.78	10.80	0.59	10.83	2.95	1.08	-0.03	-0.46
1979-89	1.70	5.84	7.65	0.54	7.90	3.03	1.30	-0.24	-0.52
1979-11	0.93	4.42	5.39	0.93	5.70	2.61	1.66	-0.29	-0.43
1995-00	1.92	4.47	6.48	2.10	6.06	4.30	2.33	0.40	-0.62
1995-11	0.39	3.78	4.18	1.30	4.54	2.42	2.02	-0.35	-0.36

Sources

[1] Unpublished BLS data.
[2] Unpublished BLS data.
[4] Based on Appendix Table 3.
[5] BEA NIPA Table 1.1.5. "Gross Domestic Product" (1973-2011).
[6] Based on Appendix Table 3.
[9] Based on Appendix Table 3.

Note

All data reflects the whole economy.

Appendix Table 3: Price Indexes (2011=100), United States, 1973-2011

	CPI-U-RS	Gross domestic product	Personal consumption expenditures		Gross private domestic investment	Government consumption expenditures and gross investment	Exports	Imports	Implicit Price Index
			All items	Medical benefits					
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
1973	21.5	24.8	23.6	11.5	34.9	19.5	35.6	25.8	21.0
1974	23.9	27.1	26.1	12.6	38.3	21.5	43.8	37.0	23.3
1975	26.1	29.7	28.3	14.0	43.1	23.6	48.3	40.0	25.4
1976	27.6	31.4	29.8	15.3	45.4	25.2	49.9	41.2	26.9
1977	29.4	33.3	31.8	16.6	48.9	26.9	51.9	44.9	28.6
1978	31.6	35.7	34.0	18.0	52.8	28.6	55.1	48.0	30.7
1979	34.6	38.7	37.0	19.8	57.6	31.0	61.7	56.2	33.7
1980	38.5	42.2	41.0	22.1	63.0	34.4	68.0	70.1	37.4
1981	42.1	46.2	44.7	24.8	69.0	37.8	73.0	73.8	40.9
1982	44.7	49.0	47.1	27.6	72.5	40.3	73.3	71.3	43.5
1983	46.6	50.9	49.2	30.2	72.3	41.9	73.6	68.7	45.4
1984	48.5	52.8	51.0	32.4	72.8	44.0	74.3	68.1	47.4
1985	50.2	54.4	52.7	34.4	73.6	45.4	72.0	65.8	49.1
1986	51.1	55.6	54.0	36.4	75.2	46.2	70.9	65.8	50.1
1987	52.8	57.2	55.9	38.8	76.6	47.5	72.7	69.8	51.9
1988	54.7	59.2	58.1	41.8	78.4	48.8	76.5	73.2	53.9
1989	57.1	61.4	60.6	45.5	80.3	50.3	77.8	74.8	56.3
1990	59.9	63.8	63.4	49.4	81.8	52.4	78.3	76.9	59.2
1991	62.1	66.0	65.7	53.2	83.0	54.2	79.3	76.3	61.5
1992	63.7	67.6	67.6	56.9	82.7	55.6	79.0	76.3	63.2
1993	65.2	69.1	69.1	60.0	83.6	56.9	79.0	75.7	64.9
1994	66.6	70.5	70.6	62.4	84.7	58.5	79.9	76.4	66.3
1995	68.2	72.0	72.1	64.7	85.7	60.1	81.7	78.5	68.0
1996	70.0	73.4	73.7	66.2	85.3	61.5	80.6	77.2	69.8
1997	71.5	74.7	75.1	67.5	85.0	62.6	79.2	74.5	71.3
1998	72.5	75.5	75.8	68.8	84.0	63.5	77.4	70.5	72.3
1999	74.1	76.6	77.0	70.3	83.9	65.5	77.0	70.9	73.8
2000	76.5	78.3	78.9	72.3	84.8	68.1	78.3	73.9	76.3
2001	78.7	80.1	80.4	74.7	85.6	70.0	78.0	72.1	78.4
2002	80.0	81.3	81.5	76.7	85.9	71.8	77.7	71.3	79.7
2003	81.7	83.1	83.2	79.6	86.9	74.9	79.3	73.8	81.6
2004	84.0	85.4	85.3	82.5	89.9	78.1	82.1	77.3	83.9
2005	86.8	88.2	87.9	85.1	94.0	82.6	85.1	82.1	86.7
2006	89.6	91.1	90.3	87.7	98.0	86.6	88.0	85.5	89.5
2007	92.2	93.7	92.7	91.0	99.9	90.7	90.9	88.5	92.1
2008	95.7	95.8	95.7	93.4	101.0	95.2	95.2	97.9	95.5
2009	95.3	96.8	95.9	96.0	100.0	94.9	90.1	87.5	95.4
2010	96.9	97.9	97.6	98.4	98.4	97.0	94.1	92.8	97.0
2011	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CAGR									
1973-11	**4.13**	**3.73**	**3.87**	**5.86**	**2.81**	**4.40**	**2.76**	**3.63**	**4.19**
1973-81	8.76	8.06	8.27	10.14	8.90	8.64	9.40	14.03	8.67
1981-89	3.87	3.63	3.90	7.85	1.91	3.64	0.80	0.16	4.07
1989-00	2.70	2.23	2.42	4.30	0.50	2.80	0.06	-0.10	2.79
2000-07	2.69	2.61	2.33	3.34	2.36	4.17	2.16	2.61	2.73
2007-11	2.06	1.63	1.91	2.39	0.03	2.46	2.41	3.09	2.08
1973-00	**4.81**	**4.34**	**4.56**	**7.06**	**3.35**	**4.75**	**2.97**	**3.97**	**4.88**
2000-11	**2.46**	**2.25**	**2.18**	**2.99**	**1.51**	**3.55**	**2.25**	**2.78**	**2.49**
1973-79	8.25	7.65	7.76	9.48	8.73	8.06	9.62	13.85	8.15
1979-89	5.13	4.73	5.06	8.70	3.37	4.95	2.34	2.89	5.28
1979-11	3.37	3.01	3.15	5.20	1.74	3.72	1.52	1.81	3.46
1995-00	2.33	1.69	1.82	2.25	-0.20	2.55	-0.85	-1.20	2.32
1995-11	2.42	2.07	2.06	2.76	0.97	3.24	1.27	1.52	2.44

Sources

[1-8] BEA NIPA Table 1.1.4 and 2.3.4. "Price Indexes for Gross Domestic Product" (1973-2011).

[9] Based on Appendix Tables 5a and 5b.

Appendix Table 4: Nominal Wage and Salary Measures, United States, 1973-2011

	Average nominal hourly earnings	Average nominal weekly earnings	Employer Costs for Employee Benefits			Nominal compensation per hour for the business sector
			Index of Total compensation	Index of Wages and Salaries	Index of Benefits	
	current dollars per hour	current dollars per week	Index: 2005 = 100			
	[1]	[2]	[3]	[4]	[5]	[6]
1973	4.14	152.77	...	...	...	17.70
1974	4.43	161.25	...	...	...	19.40
1975	4.73	170.28	...	...	...	21.40
1976	5.06	182.67	...	...	...	23.20
1977	5.44	195.30	...	...	...	25.10
1978	5.88	210.50	...	...	...	27.30
1979	6.34	225.70	...	...	...	29.90
1980	6.85	241.12	...	...	...	33.10
1981	7.44	261.89	...	...	...	36.20
1982	7.87	273.09	...	...	...	38.80
1983	8.20	286.18	...	...	...	40.40
1984	8.49	298.00	...	...	...	42.10
1985	8.74	305.03	...	...	...	44.10
1986	8.93	309.87	...	...	...	46.40
1987	9.14	317.16	...	...	...	48.00
1988	9.44	326.62	...	...	...	50.50
1989	9.80	338.10	...	...	...	51.90
1990	10.20	349.75	...	...	...	55.20
1991	10.52	358.51	...	...	...	58.00
1992	10.77	368.25	...	...	...	61.10
1993	11.05	378.91	...	...	...	62.50
1994	11.34	391.22	...	...	...	63.40
1995	11.65	400.07	...	...	...	64.70
1996	12.04	413.28	...	...	...	66.90
1997	12.51	431.86	74.90	77.60	68.50	69.10
1998	13.01	448.56	77.50	80.60	70.20	73.30
1999	13.49	463.15	80.20	83.50	72.60	76.60
2000	14.02	481.01	83.60	86.70	76.70	82.30
2001	14.54	493.79	87.30	89.90	81.30	86.10
2002	14.97	506.75	90.00	92.20	84.70	88.80
2003	15.37	518.06	93.60	95.10	90.20	93.00
2004	15.69	529.09	97.20	97.60	96.20	96.20
2005	16.13	544.33	100.00	100.00	100.00	100.00
2006	16.76	567.87	103.20	103.20	103.10	103.80
2007	17.43	590.04	106.30	106.60	105.60	108.10
2008	18.08	607.95	108.90	109.40	107.70	111.70
2009	18.63	617.18	110.20	110.80	108.70	113.50
2010	19.07	636.91	112.50	112.80	111.90	115.80
2011	19.44	653.16	...	...	...	...
CAGR						
1973-11	4.15	3.90	...	...	...	...
1973-81	7.60	6.97	...	...	...	9.36
1981-89	3.50	3.24	...	...	...	4.61
1989-00	3.31	3.26	...	...	...	4.28
2000-07	3.16	2.96	...	...	...	3.97
2007-11	2.77	2.57	...	...	...	...
1973-00	4.62	4.34	...	...	...	5.86
2000-11	3.02	2.82	...	...	...	...
1973-79	7.36	6.72	...	...	...	9.13
1979-89	4.45	4.12	...	...	...	5.67
1979-11	3.56	3.38	...	...	...	...
1995-00	3.77	3.75	...	...	...	4.93
1995-11	3.25	3.11	...	...	...	...

Sources

[1-2] Economic Report of the President 2012: Table B-47

[3-5] Economic Report of the President 2012: Table B-48

[6] Economic Report of the President 2012: Table B-49

Note

[1] For private, nonagricultural industries and for production or nonsupervisory workers

[2] For private, nonagricultural industries and for production or nonsupervisory workers

[3-5] For total private industries. Data on North American Industry Classification System (NAICS) basis available beginning with 2001 and on an SIC basis for years before 2001. Based on values for December of that year, not seasonally adjusted.

[6] Wages and salaries of employees plus employers' contributions for social insurance and private benefit plans. Also includes an estimate of wages, salaries, and supplemental payments for the self-employed.

Appendix Table 5a: Decomposition of Average Nominal Hourly Compensation, United States, 1973-2010

	Total hourly compensation	Wages and Salaries	Total Benefits	Health insurance	Pension	Social Insurance	Compensation / Wages
	current dollars per hour						ratio
	[1]	[2]	[3]	[4]	[5]	[6]	[7]=[1]/[2]
1973	5.40	4.72	0.68	0.14	0.24	0.30	1.14
1974	5.91	5.13	0.78	0.16	0.29	0.34	1.15
1975	6.48	5.56	0.92	0.19	0.35	0.37	1.16
1976	7.03	5.97	1.06	0.23	0.41	0.42	1.18
1977	7.58	6.38	1.20	0.27	0.46	0.46	1.19
1978	8.20	6.88	1.32	0.31	0.49	0.52	1.19
1979	8.94	7.48	1.46	0.34	0.54	0.58	1.20
1980	9.89	8.24	1.65	0.39	0.62	0.64	1.20
1981	10.85	9.01	1.84	0.45	0.66	0.72	1.20
1982	11.72	9.69	2.03	0.53	0.72	0.78	1.21
1983	12.26	10.10	2.16	0.58	0.74	0.83	1.21
1984	12.89	10.59	2.30	0.60	0.78	0.91	1.22
1985	13.58	11.16	2.42	0.65	0.81	0.96	1.22
1986	14.24	11.71	2.54	0.69	0.83	1.02	1.22
1987	14.80	12.21	2.59	0.72	0.82	1.06	1.21
1988	15.58	12.86	2.71	0.78	0.78	1.15	1.21
1989	16.06	13.25	2.81	0.85	0.79	1.18	1.21
1990	16.93	13.95	2.98	0.94	0.79	1.25	1.21
1991	17.88	14.64	3.24	1.04	0.86	1.34	1.22
1992	18.78	15.30	3.48	1.16	0.90	1.43	1.23
1993	19.30	15.67	3.63	1.23	0.93	1.46	1.23
1994	19.79	16.08	3.71	1.26	0.96	1.49	1.23
1995	20.22	16.55	3.67	1.22	0.96	1.49	1.22
1996	20.90	17.22	3.67	1.22	0.94	1.51	1.21
1997	21.54	17.88	3.66	1.20	0.93	1.53	1.20
1998	22.59	18.80	3.79	1.26	0.95	1.57	1.20
1999	23.60	19.68	3.92	1.37	0.93	1.62	1.20
2000	25.10	20.93	4.17	1.51	0.96	1.69	1.20
2001	26.26	21.75	4.51	1.66	1.06	1.79	1.21
2002	27.08	22.15	4.94	1.79	1.28	1.86	1.22
2003	28.48	23.00	5.48	1.97	1.53	1.98	1.24
2004	29.53	23.87	5.66	2.10	1.48	2.08	1.24
2005	30.78	24.86	5.92	2.23	1.54	2.16	1.24
2006	31.84	25.85	5.99	2.23	1.59	2.17	1.23
2007	32.99	26.94	6.05	2.29	1.58	2.18	1.22
2008	34.38	27.89	6.49	2.38	1.87	2.23	1.23
2009	35.14	28.25	6.89	2.57	2.04	2.28	1.24
2010	35.79	28.77	7.02	2.57	2.11	2.34	1.24
CAGR							
1973-10	**5.25**	**5.01**	**6.50**	**8.21**	**6.03**	**5.70**	**0.23**
1973-81	9.12	8.43	13.20	15.97	13.34	11.62	0.63
1981-89	5.03	4.94	5.47	8.14	2.24	6.26	0.09
1989-00	4.14	4.24	3.64	5.39	1.84	3.37	-0.10
2000-07	3.98	3.67	5.46	6.11	7.32	3.68	0.30
2007-10	2.76	2.22	5.08	3.89	10.20	2.36	0.53
1973-00	**5.86**	**5.68**	**6.94**	**9.25**	**5.24**	**6.61**	**0.17**
2000-10	**3.61**	**3.23**	**5.35**	**5.44**	**8.18**	**3.28**	**0.37**
1973-79	8.77	7.99	13.55	15.95	14.29	11.72	0.73
1979-89	6.04	5.89	6.77	9.67	3.85	7.25	0.14
1979-10	4.58	4.44	5.19	6.77	4.50	4.58	0.13
1995-00	4.42	4.81	2.59	4.44	0.05	2.60	-0.37
1995-10	3.88	3.75	4.42	5.10	5.40	3.05	0.12

Sources

[1] BEA NIPA Table 6.11.

Note

All data reflects the whole economy.

Appendix Table 5b: Decomposition of Average Real Hourly Compensation in 2011 dollars, United States, 1973-2010

	Total hourly compensation	Wages and Salaries	Total Benefits	Health insurance	Pension	Social Insurance	Compensation / Wages
	2011 dollars per hour						ratio
	[1]	[2]	[3]	[4]	[5]	[6]	[7]=[1]/[2]
1973	25.64	21.91	3.73	1.21	1.13	1.40	1.17
1974	25.35	21.47	3.88	1.26	1.20	1.41	1.18
1975	25.50	21.34	4.16	1.40	1.36	1.41	1.20
1976	26.17	21.65	4.52	1.52	1.47	1.52	1.21
1977	26.51	21.73	4.78	1.63	1.58	1.58	1.22
1978	26.67	21.76	4.90	1.70	1.56	1.65	1.23
1979	26.55	21.59	4.95	1.70	1.56	1.69	1.23
1980	26.45	21.43	5.03	1.77	1.60	1.66	1.23
1981	26.49	21.38	5.11	1.82	1.57	1.72	1.24
1982	26.97	21.70	5.27	1.93	1.61	1.74	1.24
1983	26.99	21.68	5.31	1.92	1.60	1.78	1.24
1984	27.20	21.84	5.36	1.86	1.62	1.88	1.25
1985	27.67	22.26	5.41	1.89	1.61	1.91	1.24
1986	28.43	22.93	5.51	1.89	1.62	2.00	1.24
1987	28.54	23.13	5.40	1.85	1.55	2.01	1.23
1988	28.91	23.51	5.40	1.88	1.42	2.10	1.23
1989	28.52	23.21	5.31	1.86	1.38	2.06	1.23
1990	28.59	23.29	5.30	1.90	1.31	2.09	1.23
1991	29.09	23.58	5.51	1.95	1.39	2.16	1.23
1992	29.73	24.04	5.69	2.03	1.42	2.24	1.24
1993	29.76	24.03	5.73	2.06	1.43	2.24	1.24
1994	29.83	24.13	5.70	2.02	1.44	2.24	1.24
1995	29.74	24.27	5.47	1.88	1.41	2.19	1.23
1996	29.94	24.59	5.34	1.84	1.35	2.16	1.22
1997	30.21	25.00	5.21	1.77	1.29	2.14	1.21
1998	31.24	25.92	5.32	1.83	1.32	2.17	1.21
1999	31.96	26.57	5.39	1.95	1.25	2.18	1.20
2000	32.91	27.35	5.56	2.09	1.26	2.21	1.20
2001	33.48	27.63	5.84	2.22	1.34	2.28	1.21
2002	33.97	27.70	6.27	2.34	1.60	2.33	1.23
2003	34.90	28.14	6.77	2.48	1.87	2.42	1.24
2004	35.22	28.43	6.78	2.55	1.76	2.48	1.24
2005	35.52	28.65	6.87	2.62	1.77	2.48	1.24
2006	35.58	28.84	6.74	2.54	1.77	2.42	1.23
2007	35.82	29.23	6.59	2.51	1.71	2.37	1.23
2008	35.98	29.14	6.84	2.55	1.95	2.33	1.23
2009	36.84	29.63	7.21	2.68	2.14	2.40	1.24
2010	36.89	29.69	7.20	2.61	2.18	2.42	1.24
CAGR							
1973-10	**0.99**	**0.82**	**1.79**	**2.10**	**1.80**	**1.49**	**0.16**
1973-81	0.41	-0.31	4.01	5.29	4.21	2.63	0.72
1981-89	0.93	1.03	0.47	0.27	-1.57	2.30	-0.11
1989-00	1.31	1.50	0.43	1.05	-0.84	0.65	-0.19
2000-07	1.22	0.95	2.46	2.68	4.51	0.96	0.26
2007-10	0.98	0.52	2.98	1.22	8.37	0.66	0.46
1973-00	**0.93**	**0.82**	**1.49**	**2.05**	**0.41**	**1.72**	**0.10**
2000-10	**1.15**	**0.82**	**2.62**	**2.24**	**5.65**	**0.87**	**0.32**
1973-79	0.58	-0.24	4.83	5.91	5.57	3.20	0.82
1979-89	0.72	0.73	0.69	0.90	-1.22	2.02	-0.01
1979-10	1.07	1.03	1.21	1.38	1.08	1.16	0.03
1995-00	2.05	2.42	0.32	2.14	-2.23	0.26	-0.37
1995-10	1.45	1.35	1.85	2.20	2.96	0.67	0.09

Sources

[1-6] Based on Appendix Table 5a and Appendix Table 3

Note

All data reflects the whole economy.

Appendix Table 6: Decomposition of GDI, United States, 1973-2011

	Gross domestic product	Gross domestic income	Gross domestic income	Paid Compensation of Employees: Wage and salary accruals	Paid Compensation of Employees: Supplements to wages and salaries	Taxes on production and imports	Subsidies	Net operating surplus: Corporate profits with inventory valuation and capital consumption adjustments, domestic industries	Net operating surplus: Other	Consumption: Private	Consumption: Government
	billions of current dollars	billions of current dollars	Per cent of GDI								
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
1973	1,382.3	1,374.3	100.00	51.58	7.46	8.53	-0.38	7.97	14.60	7.97	2.28
1974	1,499.5	1,489.6	100.00	51.85	7.92	8.38	-0.22	6.56	14.53	8.58	2.41
1975	1,637.7	1,621.4	100.00	50.26	8.28	8.34	-0.28	7.32	14.33	9.28	2.46
1976	1,824.6	1,801.1	100.00	49.96	8.86	8.13	-0.28	8.06	13.72	9.19	2.37
1977	2,030.1	2,008.9	100.00	49.49	9.28	7.95	-0.35	8.60	13.50	9.26	2.27
1978	2,293.8	2,267.7	100.00	49.42	9.48	7.54	-0.39	8.63	13.81	9.35	2.18
1979	2,562.2	2,515.3	100.00	49.83	9.74	7.16	-0.34	7.58	14.14	9.72	2.16
1980	2,788.1	2,742.9	100.00	50.07	10.00	7.30	-0.36	6.05	14.39	10.29	2.25
1981	3,126.8	3,090.3	100.00	48.91	9.98	7.62	-0.37	6.26	14.86	10.46	2.27
1982	3,253.2	3,248.4	100.00	48.88	10.22	7.42	-0.46	5.33	15.27	10.97	2.37
1983	3,534.6	3,484.9	100.00	48.14	10.27	7.56	-0.61	6.45	15.25	10.60	2.34
1984	3,930.9	3,899.4	100.00	47.32	10.27	7.43	-0.54	7.23	16.12	9.94	2.23
1985	4,217.5	4,175.2	100.00	47.49	10.28	7.38	-0.51	7.05	16.21	9.89	2.22
1986	4,460.1	4,392.3	100.00	47.90	10.37	7.36	-0.57	6.25	16.42	10.00	2.26
1987	4,736.4	4,703.5	100.00	48.00	10.19	7.39	-0.64	6.80	16.12	9.88	2.27
1988	5,100.4	5,110.0	100.00	47.76	10.07	7.33	-0.58	7.23	16.23	9.73	2.23
1989	5,482.1	5,426.0	100.00	47.63	10.11	7.35	-0.50	6.61	16.81	9.76	2.24
1990	5,800.5	5,716.3	100.00	47.99	10.24	7.43	-0.47	6.27	16.45	9.80	2.29
1991	5,992.1	5,912.4	100.00	47.65	10.55	7.73	-0.47	6.44	15.84	9.90	2.35
1992	6,342.3	6,232.3	100.00	47.51	10.81	7.76	-0.48	6.79	15.68	9.63	2.32
1993	6,667.4	6,531.6	100.00	47.25	10.93	7.70	-0.56	7.15	15.61	9.59	2.32
1994	7,085.2	6,976.4	100.00	46.62	10.75	7.81	-0.47	7.89	15.65	9.47	2.27
1995	7,414.7	7,362.1	100.00	46.71	10.33	7.58	-0.47	8.46	15.58	9.57	2.24
1996	7,838.5	7,812.5	100.00	46.39	9.87	7.43	-0.45	8.95	16.12	9.52	2.17
1997	8,332.4	8,346.3	100.00	46.46	9.49	7.33	-0.40	9.31	16.26	9.46	2.09
1998	8,793.5	8,878.8	100.00	47.14	9.49	7.20	-0.41	7.99	17.09	9.48	2.02
1999	9,353.5	9,424.6	100.00	47.43	9.43	7.15	-0.48	7.80	17.06	9.63	1.99
2000	9,951.5	10,085.5	100.00	47.91	9.53	7.03	-0.45	6.68	17.56	9.78	1.96
2001	10,286.2	10,389.5	100.00	47.72	9.89	7.00	-0.56	5.91	17.95	10.12	1.97
2002	10,642.3	10,664.4	100.00	46.91	10.44	7.15	-0.39	6.70	16.95	10.26	1.98
2003	11,142.2	11,125.5	100.00	46.38	11.04	7.25	-0.44	7.30	16.30	10.21	1.96
2004	11,853.3	11,875.6	100.00	45.61	10.80	7.27	-0.39	8.77	15.87	10.11	1.95
2005	12,623.0	12,718.0	100.00	44.92	10.69	7.31	-0.48	9.57	15.88	10.15	1.97
2006	13,377.2	13,619.5	100.00	44.62	10.33	7.25	-0.38	9.92	16.07	10.22	1.98
2007	14,028.7	14,040.7	100.00	45.74	10.26	7.32	-0.39	8.26	16.22	10.51	2.07
2008	14,291.5	14,294.0	100.00	45.87	10.65	7.27	-0.37	5.89	17.72	10.79	2.18
2009	13,939.0	13,861.5	100.00	45.34	11.05	7.34	-0.43	7.23	16.02	11.13	2.34
2010	14,526.5	14,525.7	100.00	44.18	10.76	7.26	-0.39	9.76	15.53	10.61	2.30
	Per cent change		**Percentage point change**								
1973-10	950.9	957.0	0.00	-7.40	3.30	-1.27	-0.02	1.79	0.93	2.64	0.02
1973-00	619.9	633.9	0.00	-3.66	2.07	-1.50	-0.08	-1.30	2.97	1.82	-0.32
2000-10	46.0	44.0	0.00	-3.73	1.23	0.23	0.06	3.08	-2.04	0.82	0.34

Sources

[1] BEA NIPA Table 1.1.4

[2-11] BEA NIPA Table 1.10

Appendix Table 7: Decomposition of the Gap between Productivity and Median Real Wages, United States, 1973-2011

	Labour Productivity (2011 dollars per hour)	Real Median Hourly Wage (2011 dollars per hour)	GDP / Labour Compensation	Implicit price deflator / GDP deflator	Average real compensation / Median real compensation	Median real compensation / Median real wage
	[1]	[2]	[3]	[4]	[5]	[6]
1973	33.68	15.45	155.65	84.7	141.3	117.0
1974	33.39	15.07	153.87	86.1	141.5	118.1
1975	34.29	15.11	157.47	85.7	140.7	119.5
1976	35.11	15.19	157.31	85.7	141.9	120.9
1977	35.48	15.21	157.04	85.7	142.0	122.0
1978	35.78	15.35	156.90	86.1	140.8	122.5
1979	35.92	15.21	155.91	87.1	141.5	122.9
1980	35.91	15.06	154.20	88.6	141.4	123.5
1981	36.73	14.67	156.80	88.7	145.4	123.9
1982	36.56	14.87	154.35	88.7	144.4	124.3
1983	37.54	14.79	157.86	89.2	144.8	124.5
1984	38.31	14.87	159.38	89.7	144.7	124.5
1985	39.00	15.00	159.38	90.2	145.5	124.3
1986	39.88	15.29	158.79	90.0	147.1	124.0
1987	40.12	15.30	157.69	90.7	148.6	123.4
1988	40.55	15.20	157.17	91.1	151.5	123.0
1989	40.87	15.12	159.65	91.7	150.2	122.9
1990	41.56	15.11	158.82	92.9	151.9	122.8
1991	42.06	15.20	158.40	93.1	152.1	123.4
1992	43.46	15.33	159.34	93.5	153.8	123.7
1993	43.68	15.22	159.87	93.9	154.3	123.9
1994	44.08	14.96	161.58	94.0	156.9	123.6
1995	44.10	14.84	161.63	94.4	158.8	122.6
1996	45.19	14.78	163.19	95.1	161.8	121.7
1997	45.85	15.12	163.52	95.5	160.6	120.8
1998	46.84	15.55	160.67	95.8	162.4	120.5
1999	48.16	16.03	160.70	96.4	161.3	120.3
2000	49.49	15.99	158.48	97.4	166.6	120.3
2001	50.64	16.33	158.69	98.0	164.7	121.1
2002	52.25	16.47	160.92	98.0	164.0	122.6
2003	53.85	16.66	160.88	98.2	164.8	124.1
2004	55.10	16.66	163.21	98.2	166.6	123.9
2005	55.93	16.47	164.83	98.2	169.2	124.0
2006	56.39	16.54	165.15	98.2	170.4	123.4
2007	57.07	16.40	165.17	98.2	175.0	122.6
2008	57.51	16.46	164.51	99.7	172.4	123.5
2009	58.73	16.74	166.05	98.5	172.5	124.3
2010	60.53	16.52	169.70	99.1	175.4	124.3
2011	60.77	16.07	170.95	100.0	177.7	124.5
CAGR						
1973-11	**1.56**	**0.10**	**0.25**	**0.44**	**0.61**	**0.16**
1973-81	1.09	-0.65	0.09	0.57	0.36	0.72
1981-89	1.34	0.38	0.23	0.43	0.41	-0.11
1989-00	1.76	0.51	-0.07	0.55	0.94	-0.19
2000-07	2.06	0.36	0.59	0.12	0.70	0.26
2007-11	1.58	-0.50	0.86	0.45	0.39	0.39
1973-00	**1.44**	**0.13**	**0.07**	**0.52**	**0.61**	**0.10**
2000-11	**1.88**	**0.05**	**0.69**	**0.24**	**0.59**	**0.31**
1973-79	1.08	-0.26	0.03	0.46	0.02	0.82
1979-95	1.29	-0.15	0.23	0.51	0.72	-0.02
1995-00	2.33	1.50	-0.39	0.63	0.96	-0.37
2000-11	1.88	0.05	0.69	0.24	0.59	0.31
	Gap (CAGR of [1] - CAGR of [2])			**% of Gap**		
1973-11	**1.46**	**…**	**16.9**	**29.9**	**41.4**	**11.1**
1973-81	1.73	…	5.3	32.9	20.6	41.3
1981-89	0.97	…	23.3	44.2	42.8	-10.9
1989-00	1.24	…	-5.4	44.0	75.9	-15.1
2000-07	1.69	…	35.1	7.0	41.6	15.5
2007-11	2.09	…	41.4	21.3	18.5	18.5
1973-00	**1.31**	**…**	**5.1**	**39.7**	**46.8**	**7.9**
2000-11	**1.84**	**…**	**37.6**	**12.9**	**32.0**	**16.8**
1973-79	1.34	…	2.1	34.4	1.9	61.6
1979-95	1.44	…	15.6	35.2	50.3	-1.4
1995-00	0.84	…	-47.0	74.8	114.9	-43.6
2000-11	1.84	…	37.6	12.9	32.0	16.8

Sources

[1] Appendix Table 1

[2] Appendix Table 1

[3] Based on Appendix Table 2

[4] Based on Appendix Table 3

[5] Based on Appendix Table 1

[6] Based on Appendix Table 1

Employment and Productivity: Disentangling Employment Structure and Qualification Effects

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ABSTRACT

Based on a disaggregation of the workforce into three qualification or educational attainment categories, the article estimates the effects on hourly productivity from changes in the employment rate structure and from changes in the qualification structure. 21 OECD countries are then ranked in terms of the potential gains in GDP they could expect from moving to the educational attainment rates and employment rates of the best performing countries.

RÉSUMÉ

S'appuyant sur une désagrégation de la population active en trois catégories de qualifications ou de niveaux d'instruction, cet article estime les effets sur la productivité horaire de changements de la structure du taux d'emploi et de changements de la structure des qualifications. Nous classons ensuite 21 pays de l'OCDE selon les gains potentiels de leur PIB auquel ils pourraient s'attendre s'ils atteignaient les taux de niveaux d'instruction et les taux d'emploi des pays les plus performants.

WHICH EMPLOYMENT-BASED POLICY would lead to the largest GDP per capita gains? Countries can increase either the employment rate, working time or the qualifications of the employed population. GDP per capita levels vary among industrialised countries, and at the same time we observe huge variations in employment rates, working time, and qualifications of the working-age population. For example, GDP per capita, the employment rate and working time are higher in the United States than in Continental Europe. This explains why

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improving the employment rate and the knowledge-based economy across Europe were two of the three pillars of the Lisbon Strategy, the implicit goal being to catch up with the U.S. GDP per capita level.[2] However, given trade-offs between productivity and the employment rate, and between productivity and working time, the differences observed among countries in the employment rate and in working time cannot explain differences in GDP per capita in the same proportion.

A growing amount of economic literature, using country panel data, studies the relationships between productivity and the employment rate, and between productivity and working hours. A number of studies, using different methodologies, find a negative elasticity of hourly productivity with regard to the employment rate and working time.[3] The explanation usually given for this negative elasticity with regard to the employment rate is that the most productive and skilled people are hired first. Concerning working time, it is argued that, beyond a certain number of hours, the effects of fixed costs (which produce increasing returns to hours worked) are outweighed by the effects of fatigue (which produce diminishing returns).

Although the relationship between productivity and employment is often intuitively explained in the literature by skills or demographic structure, few papers look closely at this issue empirically. An attempt is made by Bourlès and Cette (2005) who break down the employment rate into six categories based on three age groups for each gender. They find differences between the age groups: an increase in the employment rate due to an increase in employment among 25 to 54 year-olds reduces productivity by less than an increase in employment for the 15-24 and 55-64 age groups. This may reflect two human capital effects: a lack of experience in the young non-employed population and an erosion of human capital in the older bracket of the non-employed working age population.

Boulhol (2009) and Boulhol and Turner (2009) complete the analysis by integrating different qualification or educational attainment groups.[4] They distinguish 30 categories, crossing three dimensions (two genders x five age groups x three education levels) and show that the effect of the working-age population structure is dominated by the effect of educational composition. However, they use data on relative wages to evaluate productivity changes beyond these 30 categories. This approach has the advantage of distinguishing a specific effect for each country, but has the disadvantages of having to assume a perfectly competitive labour market and to rely on data concerning wages, employment structures and working-age population structures at the limit of their accuracy capacities, or beyond.

The present study aims to distinguish, within the trade-off between productivity and the employment rate, the specific role of the education structure and the specific role of the employment rate. To do so, the working age population is broken down into three categories, according to their education level: less than secondary education, some secondary education and some higher education. Unlike Boulhol and Turner, we rely on econometric methods to evaluate the effect on productivity of a change in the employment rate for each of the three educational attainment groups.

Our empirical analysis is carried out on a panel of 22 OECD countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France,

2 The other pillar was the environment, with the aim of reducing greenhouse gas emissions.

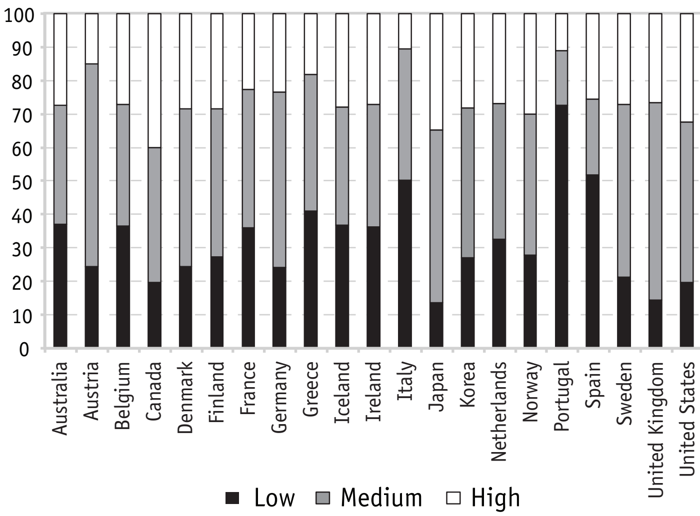
3 See Gust and Marquez (2004), Belorgey *et al.* (2006), Bourlès and Cette (2005, 2007), McGuckin and van Ark (2005), Aghion *et al.* (2009), Dew-Becker and Gordon (2008), and Cette, Chang and Konte (2011).

4 The term qualification is used in this paper in the sense of educational attainment, not skill level.

Chart 1

Educational Attainment in OECD Countries (15-64), 2005

Share, as a per cent, of each of the three education groups



Source: OECD.

Germany, Greece, Ireland, Iceland, Italy, Japan, Korea, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. The macroeconomic data span the 1980-2007 period. The main data sources are the OECD databases. Data sources are detailed in Appendix A.

Our estimates show that the negative effect on hourly productivity growth of an increase in the employment rate is greater (in absolute terms) if coming from an increase in the employment of the two first educational attainment groups than of the population with higher education. Turning to policy implications, it appears that the mechanical (simulated) gains on GDP of a catch-up with the best performing country or with the United States in employment or education structure differ significantly among countries.

The article is organized in four parts. Section one examines differences between countries in the employment rate and the education structure of the workforce and population. Section two presents the model and provides estimation results. Section three discusses policy implications. Section four concludes.

Employment and Qualification Structures

There are significant differences across countries in the educational attainment and employment rate structure of the working-age population. We highlight some important differences in 2005.

As stated in the introduction, we distinguish three levels of qualification (or educational attainment) in the working-age population (i.e. population aged 15 to 64 years): below secondary education, secondary education (completed or not) and higher education (completed or not). This educational attainment or qualification structure differs significantly among countries (Chart 1).

In 2005, the proportion of the working age population with higher education exceeded 30 per cent in only four countries: Canada (40 per cent), Japan (35 per cent), the United States (33 per cent), and Norway (30 per cent). Conversely, this proportion was below 20 per cent in four countries: Greece (18 per cent), Austria (15 per cent), Italy (11 per cent), and Portugal (11 per cent). Similarly, the proportion of the working age population with the lowest education level is very sparse. It is below 20 per cent in four countries: Japan (13 per cent), the United Kingdom (14 per cent), Canada (19 per cent), and the United States (19 per cent). Conversely, it is above 40 per cent in four countries: Greece (41 per cent), Italy (50 per cent), Spain (52 per cent), and Portugal (72 per cent).

Still, from the various proportions of the population with secondary education, it appears that the differences in the proportions of the population with the lowest level of education do not necessarily reflect similar differences in that with the highest level.

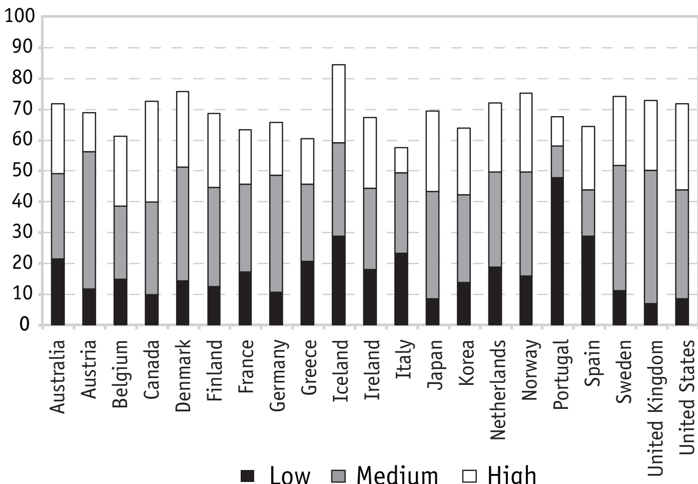
In all countries, the employment rate for the working age population with the lowest education level is below that of the population with secondary education, which is lower than that of the population with higher education. Overall, the employment rate in 2005 was very diverse across OECD countries. It is particularly high (75 per cent or more) in three countries: Norway (75 per cent), Denmark (76 per cent), and Iceland (84 per cent). It was low (below 65per cent) in five countries: Italy (57 per cent), Greece (60 per cent), France (63 per cent), Korea (64 per cent), and Spain (64 per cent). The employment rate is higher in Anglo-Saxon and Nordic countries and Japan compared to Continental European countries.

The contributions of the different education groups towards the overall employment rate (defined as the ratio between the number of employed in the education group and the total working-age population) depend both on the education structure of the working-age population and on the employment rate of each group.[5] Chart 2 shows that the contribution of the population with higher education is very low (below 15 percentage points) in four countries: Italy (8 points), Portugal (10 points), Austria (13 points), and Greece (14 points). It is on the contrary particularly high (over 25 percentage points) in six countries: Denmark (26 points), Iceland (26 points), Japan (26 points), Norway (26 points), the United States (28 points), and Canada (33 points).

The contribution to the overall employment rate of the population with the lowest level of education is very small (below 10 percentage points) in four countries: the United Kingdom (7 points), Japan (8 points), the United States (8 points), and Canada (9 points). It is on the contrary particularly large (over 25 percentage points) in three countries: Iceland (29 points), Spain (29 points), and Portugal (48 points).

Chart 2

Employment Rate (in per cent) and Contribution of each Education Group (in percentage points), OECD Countries, 2005



Source: OECD.

From these observations, we may already guess that for some countries, GDP gains from moving to the education structure and employment rate of the best performing country can be significant. In order to evaluate these gains, it is necessary to first estimate the potential GDP gains from an increase in the employment rate or from a shift upwards in the qualification structure.

Model and Estimation Results[6]

Before trying to break down the respective effects of changes in qualification level and in employment structure on productivity (effects on GDP follow immediately), let us first analyse the overall effect on hourly productivity growth of an increase in the employment rate. In the following, variables in lower case correspond to logs, Δ corresponds to first order differences and

5 The contribution of an education group to the employment rate is therefore different from the employment rate of this education group (that is the ratio between the number of employed in the education group and the number of working-age individuals in this group).

6 More estimation results are available upon request to the authors.

a subscript -i indicates that the variable is lagged by i period(s).

This first model aims to characterize the effect of changes in the employment rate (ΔER) on changes in the logarithm of hourly labour productivity (Δlp). Based on previous empirical studies (e.g. Gust and Marquez (2004), Bourlès and Cette (2005 and 2007), and Belorgey *et al.* (2006)) and according to economic theory, we also control in the estimates (i) for changes in the logarithm of hours worked (Δh) to control for the decreasing returns of this variable on hourly productivity and (ii) for changes in the capacity utilisation rate (ΔCUR), to reflect the effects of the business cycle. Finally, we test for many other controls (X_i). In the following, the only additional control variable presented in our results that we use will be the share of ICT production in total value added (IPTR). This is consistent with previous studies (e.g. Bourlès and Cette, 2005, 2007) that indicate this variable as the only other significant one among all alternative explanatory variables (investment rate, R&D spending, rate of self-employment, share of part time in employment, etc.). Therefore, the estimated relationship is the following:

$$\Delta lp = \beta.\Delta ER + \gamma.\Delta h + \varphi.\Delta CUR + \eta.ITPR + cte + u \quad (1)$$

The expected signs are negative for the coefficient of the changes in employment rate (ΔER) and for the changes in hours worked (Δh) and positive for the changes in the capacity utilisation rate (ΔCUR) and for the share of ICT production in total value added (IPTR).

The empirical analysis is carried out with annual data across a panel of 22 countries in the OECD, for the period 1986-2006 using instrumental variables (to correct for some of the measurement errors and simultaneity issues present in the model). Two tests are used to evaluate adjustment quality: the Sargan test (1958), which assesses the overall quality of the adjustment and the relevance of the instruments, and the Durbin-Wu-Hausman test (Durbin, 1954; Wu, 1973; Hausman, 1978) to check the exogeneity of the instruments.

The first column of Table 1 presents the results of the estimates of regression (1) using the "best" set of instruments (that is the smallest set that satisfies both tests). In this specification, ΔER and ITPR are instrumented. The choice of the instruments, ΔER lags, ΔGDP lags and the investment rate is consistent with both theoretical and empirical theory. The lags of the employment rate tend to reduce the bias due to measurement errors whereas the biases due to co-linearity driven by cycles can be reduced by the introduction of ΔGDP as an instrumental variable.

The estimates of column [1] give the following results: (i) a one percentage point increase in the employment rate changes hourly productivity by -0.51 per cent; (ii) a 1 per cent increase in hours worked changes hourly productivity by -0.50 per cent; (iii) a one percentage point increase in the capacity utilisation rate raises hourly productivity by 0.22 per cent; (iv) a one percentage point increase in ICT production as a share of GDP raises the growth in hourly productivity by 1.49 per cent.

As pointed out by Boulhol (2009), the above analysis (and its interpretation in terms of productivity changes due to overall employment rate variations) is silent on a key aspect of productivity: qualifications. Indeed, depending on the structure of the non-employed (who become employed after an increase in the employment rate) in terms of qualifications, the change in productivity caused by an increase in the employment rate could be very different.

Here, we choose to split the workforce into three groups according to qualification level: 1) less than secondary education, 2) some secondary education and 3) some higher education. This allows us to split the previous effect of the employment rate into two parts: the effect of the qualification structure in the workforce (for a

Table 1
Relation (2) estimates
Explained Variable: Δlp

	[1]	[2]	[3]	[4]	[5]
Relationship	**(1)**	**(1)**	**(2)**	**(2)**	**(2)**
ΔER	-0.509** (0.238)	-0.529*** (0.177)			
ΔER_1			-0.600*** (0.200)		
ΔER_2			-0.589*** (0.181)		
$ER_{1,2}$				-0.594*** (0.163)	-0.594** (0.262)
ΔER_3			-0.112 (0.294)	-0.108 (0.285)	-0.108 (0.328)
Δh	-0.503*** (0.177)	-0.583*** (0.170)	-0.555*** (0.158)	-0.555*** (0.158)	-0.555*** (0.188)
ΔCUR	0.219*** (0.064)	0.200*** (0.062)	0.189*** (0.057)	0.188*** (0.056)	0.188*** (0.049)
$\Delta ITPR$	1.492*** (0.448)	0.930*** (0.261)	0.770*** (0.214)	0.773*** (0.206)	0.773*** (0.201)
Constant	-0.064** (0.025)	-0.038** (0.016)	-0.030** (0.013)	-0.031** (0.013)	-0.031** (0.012)
Clustered standard errors	No	No	No	No	Yes
Number of observations	400	163	163	163	163
Sargan-Hansen stat.	12.675	3.565	6.396	6.377	7.548
P-value	0.1779	0.6136	0.3803	0.4965	0.3741
Durbin-Wu- Hausman stat.	28.46148	14.64888	13.23244	12.05782	
P-value	0.00000	0.00066	0.01019	0.00719	

Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%.
List of instruments:
Column 1: Δh; ΔCUR; ΔER_{-1}; ΔER_{-2}; ΔER_{-3}; ΔER_{-4}; ΔER_{-5}; Δgdp_{-1}; Δgdp_{-2}; Δgdp_{-3}; Δgdp_{-4}; INVR
Column 2: Δlp_{-1}; Δh; ΔCUR; ΔER_{-1}; ΔER_{-2}; ΔER_{-3}; Δgdp_{-1}; Δgdp_{-2}; Δgdp_{-3}; Δgdp_{-4}
Column 3: Δlp_{-1}; Δh; ΔCUR; $\Delta ER_{1,-1}$; $\Delta ER_{2,-1}$; $\Delta ER_{3,-1}$; ΔER_{-2}; $\Delta ER_{2,1}$; $\Delta ER_{2,2}$; $\Delta ER_{2,3}$; Δgdp_{-2}; Δh_{-2}
Column 4: Δlp_{-1}; Δh; ΔCUR; $\Delta ER_{1,-1}$; $\Delta ER_{2,-1}$; $\Delta ER_{3,-1}$; ΔER_{-2}; $\Delta ER_{2,1}$; $\Delta ER_{2,2}$; $\Delta ER_{2,3}$; Δgdp_{-2}; Δh_{-2}
Column 5: Δlp_{-1}; Δh; ΔCUR; $\Delta ER_{1,-1}$; $\Delta ER_{2,-1}$; $\Delta ER_{3,-1}$; ΔER_{-2}; $\Delta ER_{2,1}$; $\Delta ER_{2,2}$; $\Delta ER_{2,3}$; Δgdp_{-2}; Δh_{-2}

constant employment structure) and the effect of employment structure (for a given qualification structure). This methodology differs from the one used by Boulhol and Turner (2009) who estimate the same effects using the wages differential as a proxy for the productivity differential between qualification groups.

Instead, here we break down the employment rate into three contributions: $\frac{E}{P} = \frac{E_1}{P} + \frac{E_2}{P} + \frac{E_3}{P}$ where E_i represents the number of employed with a level of qualification i and P represents the working-age population. In the following, we will note:
$ER_i = \frac{E_i}{P}$ where ER_i is the contribution in percentage points of the education group to the

overall employment rate. This is not the employment rate of the education group i, which would be E_i/P_i.

Given this breakdown, the relationship (1) becomes:

$$\Delta lp=\Sigma_i\beta_i.\Delta ER_i+\gamma.\Delta h+\varphi.\Delta CUR+\eta.ITPR+cte+u \quad (2)$$

As employment data by qualification level are available for fewer observations than total employment (for most of the countries, data are only available from 1996 to 2005), this relationship is performed on 163 observations, concerning 21 countries (Switzerland disappears from our dataset).

In column [2] of Table 1, we first reproduce the estimates of the previous section on this reduced sample. It then appears that our main results are preserved and that this outcome can be obtained with fewer instruments. We are indeed able to obtain estimates close to those of Column [1] without instrumenting by the investment rate and with fewer lags on ER. This may indicate that there is less bias in the reduced sample. The main change between the two samples being the time period covered (due to time availability of employment rate by educational attainment), this could denote fewer measurement errors in the more recent period of our initial sample.

Column [3] of Table 1 is devoted to the estimates of relationship (2) using instrumental variables. Once again, we only present here the specification giving the best results in terms of Sargan and Durbin-Wu-Hansman tests (more estimation results can be found in the working paper version, Bourlès *et al.*, 2010). In this specification, ΔER_i (i=1, 2, 3) and ITPR are instrumented. Regarding the effect of variations in the contribution to the employment rate, it appears that (i) an increase in the employment rate caused by an increase in the employment of workers with less than higher education is significant with an elasticity of around -0.6 (respectively -0.600 for the population with less than secondary education and -0.589 for people with some secondary education); (ii) the difference between these two effects is not significant; (iii) the effect of an increase in the employment rate due to an increase in the contribution of high-skilled workers (with higher education) is negative, non-significantly different from zero and significantly different from the effects of the other categories.

These results allow us to aggregate together (in Column [4]) qualification groups 1 and 2 (that is the part of the population with secondary education and less).

As for the estimates on this aggregated employment rate, the chosen range of instruments groups together lags on productivity growth, on GDP growth on the growth of hours worked and on variations of the three contributions to the change in the employments rate (see Table 2 for the first step estimates).

The estimates give the following results: (i) an increase of one percentage point in the contribution of groups 1 and 2 significantly reduces productivity by 0.594 per cent when an increase in the contribution of high-skilled workers does not have a significant impact;[7] (ii) a 1 per cent increase in hours worked changes hourly productivity by -0.55 per cent; (iii) a one percentage point increase in the capacity utilisation rate raises hourly productivity by 0.188 per cent; (iv) a one-point increase in ICT production as a share of GDP raises the growth in hourly pro-

7 These effects cannot however be directly interpreted as information on the productivity of that particular education group. The differences between categories should not be directly interpreted as productivity gaps between persons in different education groups but rather as productivity gaps between persons in each education category who are currently not employed but would be the first to move into employment.

ductivity by 0.77 per cent. These results are totally consistent, when the comparison is possible, with the ones of the literature previously cited. The last column of Table 1 (column [5]) provides the results of the same specification with clustered standard errors of the country level.[8] The clustering method has little effect on the level of statistical significance of our results.

Policy Implications

Using the estimated results from the previous section, we now calculate for each country the mechanical (simulated) impact on the GDP level from moving to: (i) the educational attainment structure or (ii) the employment rate structure by education level of the United States or of the country shown to be the best performing. These mechanical impacts correspond to the permanent increase of the GDP per capita level (and not to the GDP per capita permanent growth rate) that countries could enjoy from moving to the education structure or the employment rate level of the best performing countries.

Using the previous notations, the impact on the GDP level in country j as a result of adopting the education level (MIES) and the employment rate structure (MIER) of a reference country r is calculated as follows:

$$\mathrm{MIES} = \sum_i \beta_i \cdot \frac{E_{ij}}{P_{ij}} \cdot \left(\frac{P_{ir}}{P_r} - \frac{P_{ij}}{P_j}\right)$$

and

$$\mathrm{MIER} = \sum_i (1+\beta_i) \cdot \frac{P_{ij}}{P_j} \cdot \left(\frac{E_{ir}}{P_{ir}} - \frac{E_{ij}}{P_{ij}}\right)$$

Concerning the impact of a change in the population's education structure, we assume the observed employment rates are constant per education level. The mechanical impact on the GDP level stems from the change in the employment structure by education group.

Table 2
First Stage Regressions for Relation (2) Estimates (column [4] of Table 1)

	(1)	(2)	(3)
Explained variable	$ER_{1,2}$	ER_3	ITPR
Δh	0.045	-0.045	-0.174
	(0.039)	(0.039)	(0.155)
ΔCUR	-0.006	0.006	0.028
	(0.015)	(0.015)	(0.061)
ΔER_{-2}	-0.926***	-0.074	-0.117
	(0.076)	(0.076)	(0.303)
$\Delta ER_{1,-1}$	1.888***	0.112	-0.294
	(0.096)	(0.096)	(0.382)
$\Delta ER_{2,-1}$	1.840***	0.160*	0.179
	(0.093)	(0.093)	(0.369)
$\Delta ER_{3,-1}$	0.814***	1.186***	-0.567
	(0.124)	(0.124)	(0.493)
$\Delta_2 ER_1$	0.927***	0.073	-0.150
	(0.047)	(0.047)	(0.188)
$\Delta_2 ER_2$	0.898***	0.102**	0.038
	(0.046)	(0.046)	(0.182)
$\Delta_2 ER_3$	0.374***	0.626***	-0.274
	(0.057)	(0.057)	(0.227)
Δh_{-2}	-0.008	0.008	-0.310**
	(0.035)	(0.035)	(0.140)
Δlp_{-1}	0.009	-0.009	0.251***
	(0.022)	(0.022)	(0.0885)
Δgdp_{-2}	0.009	-0.009	0.121
	(0.024)	(0.024)	(0.095)
Constant	0.000	0.000	0.053***
	(0.001)	(0.001)	(0.003)
Number of observations	163	163	163
R-squared	0.82	0.62	0.15

Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

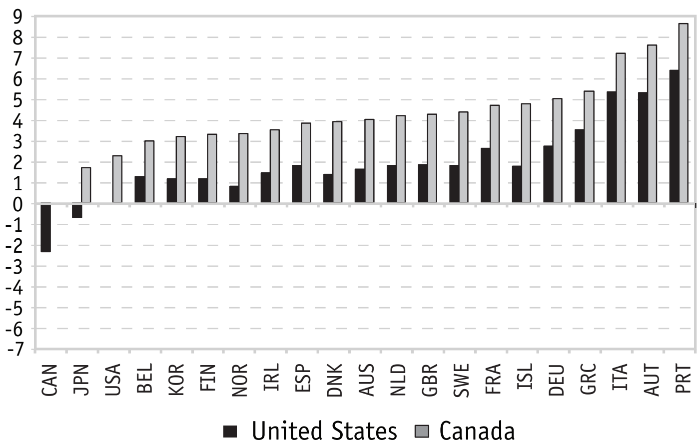
The mechanical gains in GDP resulting from moving to the U.S. education structure are above 5 per cent for three countries–Austria, Italy and Portugal–and above 2.5 per cent for three additional countries–France, Germany

8 Notice here that our variables (including the explained variable) are taken in differences, and from this possible country fixed effects in level disappear in our specification. Moreover, the small number of years used for each country (in average about eight but less for some countries) prevents us from using fixed effects in differences.

Chart 3

Mechanical Effect on the GDP Level by Adopting the Education Structure of the Working-age Population of the United States and Canada, 2005

(in per cent)

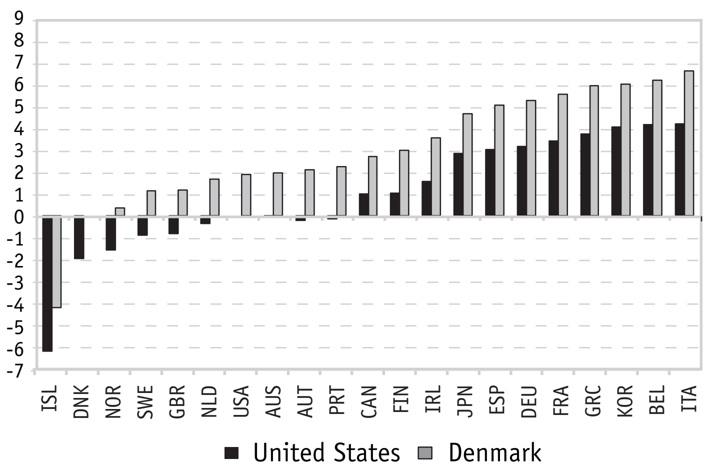


Source: Authors' calculations.

Chart 4

Mechanical Effect on the GDP Level by Adopting the Employment Rate Structure of the Working-age population of the United States and Denmark, 2005

(in per cent)



Source: Authors' calculations.

and Greece (Chart 3). Portugal has the highest potential gains: 6.3 per cent. Gains are negative in two countries where the education level of the working-age population is already higher than in the United States: Canada and Japan.

As a whole, the gains are lower than calculated by Boulhol and Turner (2009, Figure 8.4.A) for two reasons. First, Boulhol and Turner distinguish 30 groups, crossing three dimensions (two genders x five age classes x three education levels), whereas we distinguish only two or three groups in one dimension, the education level. Second, we estimate the productivity–education elasticity, assuming that the elasticity is constant over all countries, whereas Boulhol and Turner (2009) allow it to vary across countries by the wage costs, under the assumption of a perfectly competitive and efficient labour market. This assumption may lead to an overestimation of the productivity of high-skilled workers who may extract rent from the employer and are paid more than their marginal productivity.

Canada is the country with the highest proportion of its working age population with higher education, at 40 per cent in 2005.[9] GDP gains are therefore higher when adopting Canada's education structure than when adopting that of the United States.

Let us now turn to the impact of a change in the employment rate structure while keeping the population's education level constant. Due to decreasing returns of the employment rates, a general increase in the employment rate mechanically decreases the productivity level, which reduces itself the positive impact on the GDP level of the increase in the employment rate.

The GDP gains obtained by adopting the employment rate structure of the United States

9 It can be noted that many Canadians with post-secondary education have, in fact, a community college qualification and not a university degree. Considering that all countries have particular specificities, and that we are aware for only few of these particularities, we do not take them into account in our analysis. This reinforces the point that our results have to be considered carefully, as in the case for all country panel econometric studies.

are never above 5 per cent (Chart 4). They are above 2.5 per cent for eight countries: Japan, Spain, Germany, France, Greece, Korea, Belgium, and Italy. In Italy, they are the highest at 4.2 per cent. Gains are negative in nine countries, where the employment rate is higher than in the United States: Iceland, Denmark, Norway, Sweden, the United Kingdom, the Netherlands, Australia, Austria, and Portugal. These results are consistent with those of Bourlès and Cette (2005, 2007).

The highest total employment rate was observed in Iceland (84.4 per cent). This cannot however be considered as representative since the country is very small (the working-age population is less than 200 thousand). Denmark, with the second highest employment rate (75.5 per cent), is therefore considered as the best performing country. The GDP gains obtained by moving to Denmark's employment rate structure (for each educational level) are consequently higher than those obtained by moving to that of the United States.

The results demonstrate that increasing the education level or the employment rate of the working-age population are, for many countries, two effective policies to raise GDP.

Conclusion

This analysis should of course be viewed with caution, as it relies on inevitably fragile estimates conducted on a panel of OECD countries. Each country has specific institutions and labour market regulations which can explain specific effects. The estimates, nevertheless, suggest promising gains in GDP, which could be obtained in some industrialised countries after undertaking ambitious reforms to increase the education level or the employment rate of the workforce. A next step in this analysis could be to look at the impact of the interactions between changes to the education structure and rigidities in labour and product markets (in line with Aghion *et al.*, 2009). Due to serious measurement errors and endogeneity bias among these variables this however calls for more work, in particular on the instrumentation techniques.

References

Aghion, P., P. Askenazy, R. Bourlès, G. Cette, and N. Dromel. (2009) "Education, market rigidities and growth," *Economics Letters*, Vol. 102.

Belorgey, N., R. Lecat. and T. Maury (2006) "Determinants of productivity per employee: An empirical estimation using panel data," *Economics Letters*, Vol. 91, No. 2.

Boulhol, H. (2009) "The effects of population structure on employment and productivity," OECD Economics Department Working Paper, No. 684.

Boulhol, H. and L. Turner (2009) "Employment - productivity trade-off and labour composition," OECD Economics Department Working Paper, No. 698.

Bourlès, R. and G. Cette (2005) "A comparison of structural productivity levels in the major industrialised countries," *OECD Economic Studies*, 41, 2005/2.

Bourlès, R. and G. Cette (2007) "Trends in Structural Productivity Levels in the Major Industrialised Countries," *Economic Letters*, Vol. 95.

Bourlès, R., G. Cette A. and Cozarenco (2010) "Employment and productivity: disentangling employment structure and qualification effects," GREQAM working paper, 2010-03.

Cette, G., S. Chang, and M. Konte (2011) "The decreasing returns of working time:an empirical analysis on panel country data," *Applied Economics Letters*, Vol. 18, pp. 1677-1682.

Dew-Becker, I. and R. Gordon (2008) "The Role of Labor Market Changes in the Slowdown of European Productivity Growth," NBER Working Paper No. 13840.

Durbin, J. (1954) "Errors in Variables," *Review of the International Statistical Institute*, Vol. 22.

Gust, C. and J. Marquez (2004) "International Comparisons of Productivity Growth: The Role of Information Technology and Regulatory Practices," *Labour Economics*, Vol. 11.

Hausman, J. (1978) "Specification Tests in Econometrics,", *Econometrica* Vol. 46, No. 3.

McGuckin, R. and B. van Ark (2005) "Productivity and participation: an international comparison," University of Groningen, GGDC Research Memorandum, No. 2005-78.

Sargan, J. (1958) "The Estimation of Economic Relationships Using Instrumental Variables," *Econometrica*, Vol. 26, No. 3.

Wu, D.M. (1973) "Alternative Tests of Independence between Stochastic Regressors and Disturbance," *Econometrica*, Vol. 42, No.3.

Appendix: Data Sources and Variable Definitions

	Description	Sources	Mean 22 countries* (400 obs)	Standard-deviation 22 countries* (400 obs)	Mean 21 countries* (163 obs)	Standard-deviation 21 countries* (163 obs)
LP	GDP constant prices per hour worked	OECD data	32.65	8.57	35.20	8.82
H	Average annual hours actually worked per worker	OECD: Labour market	1 761	262.06	1 745	271.64
ER	Employment/population ratio	OECD: Labour market	0.66	0.08	0.67	0.07
CUR	Capacity utilisation rate	OECD: Monthly economic indicators	0.8178	0.0356	0,8169	0.0375
ITPR	Share of ICT production in total value added (current price)	STAN data	0.06	0.02	0.06	0.02
INVR	Total investment in volume as a % of GDP	OECD: Economic Outlook	0.21	0.04	0.22	0.04
GDP	Gross domestic product in USD millions, constant prices, constant PPPs, reference year 2000,	OECD: National accounts	1 127 343	1 936 387	1 131 987	1 948 684
ERp	Employment rate of population with below upper secondary education.	OECD: Boulhol			0.53	0.08
ERs	Employment rate of the population with upper secondary education.	OECD: Boulhol			0.70	0.08
ERt	Employment rate of the population with tertiary education.	OECD: Boulhol			0.81	0.05
ER1	The contribution to the employment rate of the group with "below upper secondary" education	Using OECD data			0.19	0.10
ER2	The contribution of the employment rate of the group with "upper secondary" education	Using OECD data			0.30	0.09
ER3	The contribution to the employment rate of the group with "tertiary" education	Using OECD data			0.18	0.06
P1/P	Population with less than upper secondary education - total population ratio	Using OECD data			0.35	0.15
P2/P	Population with upper secondary education - total population ratio	Using OECD data			0.42	0.11
P3/P	Population with tertiary education - total population ratio	Using OECD data			0.23	0.08

* The 21 countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Iceland, Italy, Japan, Korea, the Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom and the United States. The 22 countries are these 21 and Switzerland.

To Capture Production or Well-being? A Review Article on *Towards Measuring the Volume Output of Education and Health Services: A Handbook*

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ABSTRACT

This review article evaluates the report *Towards Measuring the Volume Output of Education and Health Services: A Handbook* produced by the OECD. Traditionally, input costs have been used to estimate the value of education and health services. The *Handbook* provides detailed analysis and recommendations regarding appropriate methodologies and data to improve volume output measures for these services. The author welcomes the efforts of the OECD in this area. However, it is argued that output measures should focus on the estimates of the volume of production of these services rather than their social valuation. As such, unit costs should be used as weights when aggregating outputs rather than marginal social valuations, which introduce a degree of subjectivity.

RÉSUMÉ

Ce compte rendu critique évalue le rapport de l'OCDE *Towards Measuring the Volume Output of Education and Health Services : A Handbook*. Par le passé, les coûts des intrants de l'éducation et des services de santé étaient utilisés pour les estimations de la production de ces industries. Le *Handbook* présente une analyse détaillée et des recommandations sur les données et les méthodologies appropriées pour améliorer les mesures de la production réelle pour l'éducation et les services de santé. Les tentatives de l'OCDE dans ce domaine sont très bienvenues. On soutient toutefois que les mesures des extrants devraient mettre l'accent sur l'exactitude de la mesure de la production de ces services dans les comptes nationaux plutôt que sur leur valeur sociale. Les coûts unitaires, plutôt que des valeurs sociales marginales, qui introduisent un certain degré de subjectivité, devraient par conséquent être utilisés comme poids pour l'agrégation des résultats.

NATIONAL ACCOUNTS HAVE BECOME a central source for evaluating living standards. Headline numbers of GDP are compared, policy makers worry about trends, and researchers delve into details. However, a rather large deficiency exists in national accounts coverage of industries that are becoming increasingly important in advanced economies: health and education services. It is this

1 The author is Chief, Policy Analysis Section in the Economic Studies and Policy Analysis Division of Finance Canada. I would like to thank Sir Tony Atkinson, Barbara Fraumeni and Andrew Sharpe for very helpful comments. The opinions expressed in this study are those of the author and do not reflect in any way those of Finance Canada. All the other usual caveats apply. Email: abIorwerth.Aled@fin.gc.ca.

gap that Paul Schreyer, Deputy Chief Statistician at the OECD, seeks to fill in *Towards Measuring the Volume Output of Education and Health Services: A Handbook* (Schreyer, 2010).[2]

Researchers have expressed concern regarding indicators of output volumes of many service sectors in the national accounts. But this shortcoming is particularly severe for education and health services, which are largely provided by government, since there are limited market output values or prices. Even if some share of output is provided by the private sector, the partial coverage by insurance or significant government involvement in price setting will mean that prices are not meaningful indicators of consumer choice or marginal valuation. As *The Economist* (2012) noted, "Americans spent $2.6 trillion on healthcare in 2010 ... yet few of them have the faintest idea what any treatment costs or how it compares with any other treatment." Although prices for attending private-sector firms are available, one might be leery of applying these prices to their public-sector equivalents.

As a result of these problems, the national accounts traditionally incorporate these services at input cost: the value of output of education is equal to the value of all the inputs used in its production. In turn, this output=input treatment implies that the national accounts have nothing interesting to say about their productivity: it is always unitary and its growth is zero. This treatment can distort the national accounts, as the measure of aggregate real output of education and health services is not particularly meaningful. Given that many of these services are provided by government, this treatment may even contribute to popular depiction of government as a consumer of resources rather than a producer of services! Indeed, I was surprised to learn in reading the *Handbook* that during the formative years of national accounting, some did not feel that government services contributed to GDP.[3]

Over recent years, statistical agencies have started to move to rectify this situation by developing more sophisticated measures of government output. Professor Anthony Atkinson reviewed many new practices and offered further guidance at the behest of the Office of National Statistics (ONS) in the United Kingdom (Atkinson, 2005).[4] Paul Schreyer's task in this *Handbook* is the more daunting prospect of going from the ideal approach to the practical, and delivering concrete suggestions for output measures covering health and education services for inclusion in the national accounts, and this on a comparable international basis.

The *Handbook* is the latest instalment of the OECD's efforts to bring some degree of coordination and comparability in data design and statistical methodologies between member states for education and health services.[5] Of course, in addition to basing recommendations on statistical or economic theory, the advice of the OECD on suitable output measures will be taken bearing in mind whether international data will be available. Although trends over time in output for one country are informative by themselves,

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2 The handbook, released by the OECD as Statistics Directorate Working Paper 2010/02, can be accessed at http://www.oecd.org/LongAbstract/0,3425,en_2649_33715_45115957_1_1_1_1,00.html

3 Non-market production has been fully recognized as contributing to GDP since the 1968 System of National Accounts (Schreyer, 2010).

4 For a discussion of the *Atkinson Review*, see ab Iowerth (2006).

5 This *Handbook* is an update of OECD (2007). *Eurostat* also plays a driving role, probably because budget transfers in Europe are linked to nominal GDP per capita and hence a consistent basis for defining GDP is required. Steps in North America are more tentative. Gu and Wong (2010) experiment with different approaches in education for Canada. The U.S. Bureau of Economic Analysis has conducted research in a number of areas but they judge their research to be preliminary and recommend further research (BEA 2011:9-4). Further analysis for the United States is conducted in Abraham and Mackie (2005). The Australian experience is discussed in Trewin (2004).

there is scope for significant insight if international comparisons of both levels and growth could be made.

There are several practical challenges in moving to output measures for health and education services that are independent of input measures. First is the obvious challenge of developing or obtaining data on output. A second difficulty is incorporating the impact of quality change. Finally, the appropriate weighing for aggregating different types of education and health services is unclear. There are related methodological problems. Clearly much work has been done by the OECD, particularly for education, but challenges remain, notably in measuring quality of health-care provision. It is therefore likely that the *Handbook* will remain a work in progress, and be regularly updated as new methods and data are developed. This conclusion is clear to the OECD as well, given their use of the word "towards" in the title of this volume.

The *Handbook* is mostly aimed at practitioners in the field. A certain amount of background in national accounting is needed to understand the various concepts. Given the very broad area that the *Handbook* covers, some additional illustrative real-world examples of various issues for a general reader may have been suitable. Indeed, for users of the national accounts such as myself, a short companion piece by the OECD to explain more succinctly the advantages and appropriate use of the data may be useful at some point. In this review article, I propose to spend most of my time in explaining some of the key concepts for a more general audience.

I welcome the efforts undertaken in developing this *Handbook*. However, I would have liked greater clarity in the *Handbook* when discussing production of health and education services. These are produced services, so their estimation in the national accounts should be akin to production of other services. There are no prices for the output of health and education and consequently researchers have undertaken considerable effort to develop marginal social valuations of these services. These valuations could be used to aggregate and value outputs, a stance which the *Handbook* seems to support in principle.

But this seems to me to step beyond the role of the national accounts in valuing production. At this time, given the enormous difficulties in developing adequate and objective valuation metrics, it may be a step too far to incorporate these valuations in the national accounts. In this respect, I echo the view of Murray (2005) and Heikkinen and Hautakangas (2008) that the national accounts should focus on production rather than trying to incorporate social valuations. In the end, the *Handbook* favours using unit costs because of practical concerns related to developing adequate marginal valuations. But, for clarity, perhaps the *Handbook* should have been restricted to the valuation of production. Indeed, making contributions to improved measurement of output volumes is a major contribution in itself.

In the first main section of the article, I discuss why improving the national accounts, and hence improving volume output measures of education and health services, is desirable. In section two, I outline some of the key concepts in the area of measuring non-market output quantities and values. Section three provides a more detailed review of the *Handbook*. Section four concludes.

The Desirability of Improving the National Accounts

The national accounts play several crucial roles in understanding the state of the economy. They provide estimates of the value of economic activity, show the allocation of resources by industry, expenditure category, and income group, and allow for an assessment of trends in living standards. This information can be used to identify areas where performance can be improved.

Although many metrics may exist to determine the performance of individual workers or institutions such as hospitals or schools, there is value in developing national accounts-compatible measures for the education or health system as whole. Such measures would allow better monitoring and analysis of economy-wide resource allocation issues. There is concern, for example, regarding the growing share of resources being allocated to healthcare (Hall and Jones, 2007). However, debate on whether this is inappropriate cannot advance unless there is evaluation of how effectively these resources are being used, and whether they lead to commensurate increases in output and welfare.

The contribution that national accounts-based measures could make is illustrated by preliminary research cited by the *Handbook* in Deveci *et al.*(2008). They examine output measures for Danish healthcare, and find that the input-price index increases by much more than the output-price index, independently of output. Using the output price index to deflate total expenditures would lead to a greater growth in healthcare volume output than if input prices were used. Such findings buttress arguments that increased spending on heathcare is productive (or of course the reverse if opposite results were found).

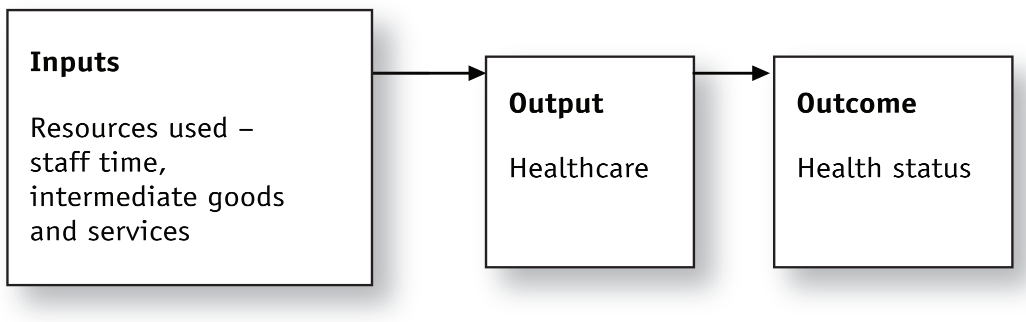
To the extent that education and health services are provided by government, a second role is improving government productivity. With increasing pressure in these times of austerity to ensure that government is efficient, the absence of meaningful, reliable, and accurate output measures means that incorrect assumptions may be made on the opportunity cost of cutting spending, or on drawing useful lessons on how government productivity can be improved. This is not a new challenge. Responding to spending increases in earlier times, economists writing on the importance of measuring government output asked: "Has the government's productivity declined so that part of the rise in input reflects the need for more resources in order to maintain a given volume of services? Or has productivity risen, thereby causing government's output to rise even more rapidly than its input?" (Fabricant and Lipsey, 1952).

Better volume output measures for health and education services may also give governments pause before spending additional resources since these resources may not result in significantly increased output. Increasing output may involve difficult institutional reform, not just spending additional resources, so developing output measures can therefore encourage such fundamental reform. Ensuring that resources are spent effectively is difficult when there is a paucity of appropriate data; better data allow better questions to be asked. The Ontario Government recently established a commission headed by Don Drummond to examine fiscal challenges in the province. Their report (Commission, 2012:13) signaled a clear and important role for better information on the output and outcomes of government activities:

> The best public service would set clear objectives, use proper metrics to measure progress and provide clear accountability for those expected to meet the objectives. It would benchmark itself against the best in the world. It would constantly evaluate priorities; if a new priority is identified, others would move down a spot and some, now outdated, would be discarded. It would drive relentlessly towards effectiveness and efficiency.

It should be borne in mind, however, that data gathered as metrics to improve performance within particular institutions may not be appropriate for the national accounts. For example, as discussed in Atkinson (2005), performance indicators need to be simple and precise, but not necessarily consistent over

Chart 1
The Definition of Inputs, Output, and Outcome: An Example from Healthcare



time. On the other hand, data produced for the national accounts can be transformed in complex ways, but do need to be consistent over time.

Finally, GDP, for better or for worse, has become an indicator of living standards. But the current treatment of non-market services means that information contained in the national accounts is inadequate for an evaluation of living standards and their growth, especially across countries with different national conventions for measuring real government output and with different shares of non-market services in GDP.[6] Analysis must differentiate between results based on the business sector or on a total-economy basis. The current shortcomings of measuring non-market output are reflected when knowledgeable researchers exclude this sector from their calculations of productivity growth. Indeed, in its assessment of the adequacy of measures of economic performance the Stiglitz Commission argued that it is important to come to grips with measuring non-market output in order to have a satisfactory measure of economic performance and living standards (Stiglitz *et al.*, 2009).

Economic Concepts, Theory and the National Accounts

Outputs versus Outcomes

Before embarking too far in this review, definitions of inputs, output, and outcomes are needed (Chart 1). As with all goods and services, production of education and health services involves the transformation of inputs into outputs. Inputs issued in the production of education and health services have the same purpose as for market-provided goods and services. For example, inputs would include the hours worked by teachers, the capital consumption from the capital goods such as computers, and intermediate inputs such as teaching supplies as intermediate goods. The time of healthcare staff and intermediate inputs such as pharmaceuticals are the inputs into hospital production. It is these costs that are currently—and inappropriately—recorded as the "output" of non-market services under the traditional method of national accounting.

6 For 2008, the OECD reports that 6.1 per cent of the OECD's GDP is spent on education with several countries spending more than 7 per cent (OECD, 2011a). Just less than 9 per cent of GDP was spent on health with the United States at over 16 per cent of GDP (OECD, 2011b). As discussed in Box 1, the *Handbook* undertakes a preliminary analysis of incorporating secondary education outputs into the national accounts. This would, for example, raise Germany's GDP per capita from 5 per cent above the OECD average using the current approach to 7 per cent. In contrast, Sweden's GDP per capita would be reduced from 10 per cent above the OECD average to 8 per cent.

A challenge in measuring the non-market sector is the distinction between what is produced—which is measured by "output"—and what society values—which is measured by "outcome". Normally, one might think of a widget as the output produced by an industry, and consumers gain utility from consuming that number of widgets, so output and outcome are the same.

The situation with non-market goods and services is more complicated:

- There is no market for the output and therefore it is hard to identify and agree upon what constitutes output. Many indicators and proxies exist, but they need to be sorted into what are the most appropriate indicators for either output or outcome. This sorting out requires understanding the structure of the sector in question; and
- The output from institutions supplying non-market services contributes only a part of the outcome. The individual efforts of students also contribute to the education outcome as well as the output of education institutions.

In turn, the distinction between outputs and outcomes is important when interpreting data. Are the data to record production of a good or service independent of outcomes, or are they to directly measure "social welfare" or well-being? I would argue that it is more important for the national accounts to accurately capture the output of health and education services in terms of production rather than the value society places on that output. First, having accurate measures of production is important in its own right and, second, the social value of education and health services is too subjective to be put in the national accounts.

Smith and Street (2007) report that there was no consensus among participants at a workshop on the measurement of education and health services about what constitutes the primary purpose of education. For education as a whole, one may think that the outcome is an "educated person", but one can well imagine the philosophical quagmire as one tries to place an economic value on such an outcome, or even agree on its quantification. The education system's output contributes to the desirable outcome—whatever that is—and it is that output from production that the national accounts should try to capture. Furthermore, the final outcome often comes from both the production of either health or education services on the one hand, and individual effort on the other. For example, education outcomes come from the output of the education system—teachers in front of a class—and the endeavour of pupils. This joint production means that outcomes cannot be used to give information on the structure of production.

One of the key tasks in the *Handbook* therefore is to provide clear guidance on what constitutes appropriate measures of outputs within the context of the national accounts, and it does this. For example, test scores are results of education, but they are the joint result of education and individual effort. As such, the *Handbook* argues they are an inappropriate measure of education output but they could instead be appropriate proxies for outcomes. What appropriate means in this area may be a subject of debate and the *Handbook* goes through its justifications of why certain measures are adopted and why some are rejected in considerable detail.

Implications of outputs differing from outcomes

There are additional challenges the *Handbook* must tackle beyond recommending particular output measures. In the simple case of market-provided goods, the statistician obtains a series of prices and quantities. From these two series, the usual formulas of index theory can be used to derive measures of real output and productivity growth. However, neither of these series is normally available for non-market goods and services. The *Atkinson Review* made substantial contributions in showing the importance of obtaining reliable measures of output quantity for non-market services, but delved less deeply into certain intricacies. Two challenges in particular remain in this regard. The first and more basic challenge for non-market goods and services is that there are no price indexes. The second challenge— common to market-provided goods as well—is to account for quality change.

Weights

The absence of prices indexes is a problem because aggregation of quantities is normally done using prices as weights. Prices reflect the marginal utility on social value a consumer places on a product and therefore act as a suitable weight in aggregating. Consequently, even if satisfactory volume indexes for different types of non-market outputs could be compiled, the absence of prices means that the challenge of aggregating these volume indexes remains. Can appropriate weights be found to substitute for prices?

Diewert (2010) examines the implications of using different measures for valuing and aggregating quantities, given that some information may not be available to the statistician. His suggested hierarchy of appropriate weights for valuing non-market outputs is:

1. Market prices or purchaser's valuation (first best);
2. Producers' unit costs of production (second best); and
3. An output-price growth rate equal to an index of input-price growth (third best).

The third of these is the practice currently employed in many countries when there are no data available on volume outputs. In other words, the only proxy we have for changes in output prices is changes in input prices. But in many cases, some data exist on prices, so the question is whether there are enough data to adopt the first- or second-best approach.[7]

If some market price data are available on market goods comparable to non-market goods (e.g. education provided by private schools), hedonic methods could be used to estimate prices. An interesting approach discussed by Diewert is to introduce output measures of non-market services as inputs into sectors of the market economy within an estimated general equilibrium model. Although requiring too much information to be practicable at the moment, this approach would in theory allow implicit prices for non-market services to be derived.[8]

Given the absence of either direct price data or of data for comparable market-provided goods and services, one is lead to a dilemma when proposing weights for output volumes of health and education. Diewert notes that "For many purposes (including the measurement of welfare), the desired conceptual price for each type of medical service is a *household marginal valuation price* or a *final demand price*, i.e. the price that a household would be willing to pay for an extra unit of the service. But it is difficult for experts to agree on what the appropriate final demand prices should be. This lack of

7 Diewert (2008) examines the implications of different approaches in the absence of comparable market prices and in the presence of quality change. He demonstrates that using costs as weights can generate measures of productivity growth that are informative—relative to the use of only input cost data—if data are available to calculate input requirement per unit output. However, these indexes may be misleading in the presence of technological change.

8 A similar notion is used in Wang *et al.* (2009) for banking. They argue there is no clear basis for measuring the output of banks, as they often do not charge explicit fees for services but instead make money from the spread between interest rates charged and paid. To incorporate the systematic risk of bank loans, the authors employ a dynamic, stochastic, general equilibrium model to clearly derive and define the marginal unit of bank output.

expert consensus puts statistical agencies in a difficult position since their estimates of output and inputs should be *objective* and *reproducible*." (Diewert, 2008:4). These arguments would seem to militate against using marginal valuations that are surrounded by controversy.

The *Handbook* reluctantly concludes unit costs— Diewert's second-best approach— should be used as weights on practical grounds, although the *Handbook* is also sympathetic for some sort of marginal valuation by consumers. Other arguments advanced in the *Handbook* to support using costs include:

- Even if prices were observable, they are heavily distorted in this area by the presence of information problems, monopolistic suppliers and—in the case of health services—that observed prices would be based on insurance valuations rather than willingness to pay; and
- In a democracy, the valuations placed on services could reflect social preferences for them. As such costs are reasonable proxies for willingness to pay.

There is some equivocation in the *Handbook* on appropriate weights for aggregation, a discussion that merits greater clarity. The nature of weights is not a major topic with market-provided goods and services. For such goods and services, the marginal valuation placed by society is the price paid for it and, if we further assume perfect competition, then that price equals the marginal cost. As a result, the distinction between output and outcome is not normally a conceptual barrier because marginal social value equals marginal cost. Of course, there remain issues of imperfect competition or externalities driving a wedge between society's valuation and the cost of production. However, for non-market goods and services where outcomes are not the same as outputs, I would argue that costs would be more closely linked to output whereas marginal social valuations are linked to outcomes.

It would seem to me that the national accounts should reflect the value of production, and this would argue in favour of using costs as weights. This approach has several additional merits:

- Overall consistency in the national accounts. There is no convention in the national accounts for looking at externalities—pecuniary or non-pecuniary. Goods are included at the price paid, not at prices consumers should pay for them, even if they do have spillovers. As mentioned in the *Handbook*, the benefit of installing air bags in cars is not reflected as a value to consumers beyond additional costs reflected in auto-sector output; and
- Introducing a separate measure of willingness to pay may end up with the value of output not equal to the value of inputs, and the need for the resultant surplus or deficit to be reflected as some sort of profit or transfer elsewhere in the accounts.

Quality

Incorporating quality changes is a general challenge in the national accounts. Hedonic approaches have gathered interest in recent times. But with the general absence of data, the problem of incorporating quality may be even greater in the non-market sector. The problem is particularly acute in health services as new treatments and drugs become available.

Stratification of the data is an implicit way of controlling for quality: different qualities of a product will be treated as different products.[9] The quality of a secondary education differs from a post-secondary education, so stratification reflects the fact that different qualities of service will be provided at different costs and

9 Aizcorbe *et al*. (2003) examines the finer disaggregation as an alternative to hedonic methods in controlling for quality differences for microprocesors. They quote Zvi Griliches saying that 'If you have the right kind of data, you don't need hedonics.'

that outputs cannot be simply added up: adding up the number of pupils in secondary schools and the number of students in university and calling the sum the output of the education sector is not suitable. Finer disaggregation will also allow resource reallocation to be detected.

Direct methods of incorporating quality may also need to be adopted through adjusting volumes or weights. In this case, the *Handbook* argues that outcome measures should be used to adjust outputs so that quality may be taken into account. Here again, however, one runs into the issue of subjectivity, as there may be disagreement on which outcomes are more important.

Although there is extensive discussion of potential quality metrics in the *Handbook*, there is a reluctance to strongly advocate for particular measures. This is probably the appropriate approach. The *Atkinson Review* recommended that while priority should be given to work on quality-adjusting outputs, "a relatively high threshold should be set for their introduction into the National Accounts; in particular, ONS should not introduce quality adjustments until it is assured that the dimensions covered are sufficiently representative." (Atkinson, 2005:191).

As a side note, there is no discussion in the *Handbook* of using some of the quality measures to correct for the quality of inputs; indeed, some of the quality measures discussed may be more appropriate for use in this manner.

The Handbook: An Overview

Turning now to the contents of the *Handbook*, its first chapter outlines conceptual issues, which forms the basis for the analysis and guidance in the chapters that follow. A major contribution of the *Handbook* is the clear link between the theory and the guidance on appropriate output measures. The second and third chapters analyze the appropriate indicators for the output of the education sector, the second chapter over time and the third across countries. Chapters four and five repeat the pattern for health services. There is much discussion of the economic concepts and how they relate to the principles of national accounting. Tables are included for cross-country comparisons of current practices. A second major contribution of the *Handbook* is documenting the large amounts of input received not only from national accountants, but also from specialists in education and health. There is extensive discussion of different measures and methodologies across countries.[10]

As mentioned, international comparisons will be informative in these critical non-market services because of the different institutions and policies followed across countries. In this respect, comparison of the output levels will be required, which necessitates some form of purchasing-power parity adjustment for education and health services. Making strides in this direction provides a clear justification for the OECD to help coordinate development of education and health indicators. They make some progress in this regard in the *Handbook*.

The *Handbook* lays out a clear path on developing measures of education and health services output, and it is worthwhile to outline that path before looking at the details.

The areas of health and education are too large to be useful units. Consequently, the first step is to stratify both areas into units of "production": primary schools, secondary schools, etc. As well as grouping production units so that their production functions are roughly similar, stratification makes it easier for outputs to be grouped according to their quality. In turn, it would also allow technological change in the

10 The *Handbook* focuses on education and health services and does not discuss public administration. Yet the problems inherent in measuring volume output in public administration are similar to those for education and health services as the output is also non-marketed.

provision of a service to be detected and accounted for.

Given these units of production, the second step is to develop volume measures for each type of output. At this stage the *Handbook* provides useful rationales, based on both economics and data availability, about what would constitute satisfactory output measures.

The third step is to explicitly incorporate quality of output into the analysis beyond what has already been implicitly factored in through the stratification procedure in step one. Direct measures of quality can be incorporated such as test scores in education.

The fourth step is to develop methods to enable international comparisons of outputs. This stage involves development of some metric that allows upward or downward revision of volumes—analogous to purchasing-power parity—so that output is based on a common metric across countries.

Although the path above is clear, difficult conceptual issues and issues of data availability make its application difficult, particularly for quality measures. As the Stiglitz Commission noted, "While there are methodological disagreements about how to make the adjustments to quality or how to go about measuring output, there is a broad consensus that adjustments should be made, and even about the principles which should guide such adjustments. The disagreements arise in the practical implementation of these principals." (Stiglitz *et al.*, 2009:12).

The *Handbook* makes progress along the path outlined above for education and health. But data problems mean that completely satisfactory results are not available at this time. In particular, although there is extensive discussion of the quality of healthcare output, the *Handbook* does not put forward proposals for explicit quality adjustment.

The challenges involved in looking for metrics in health and education differ. There is far more heterogeneity in output of health services, since individual treatments differ in all sorts of minor ways. On the other hand, the outcome—health status—is relatively clear. By contrast, the outputs of education are relatively clear—such as the number of students—but what should be the desired outcome is less so.

Measuring Education Output

The *Handbook* starts by adopting UNESCO's definition of education as the "organized communication of knowledge" as the basis for finding output measures. Stratification of education production follows the conventional separation of education leading to nine levels in total, such as by pre-primary, primary, secondary and post-secondary education. Although this seems like a detailed breakdown, my experience is that comparing post-secondary institutions across countries (or even across provinces in Canada) is quite complicated because of the mix of vocational and academic programs at some institutions.

The volume of output for these institutions is suggested to be the number of pupil-hours for primary and secondary education to reflect the provision of service to the pupil. The output is less clear for tertiary education since a much larger part of the education process is work by the student rather than the education institution. Consequently, the *Handbook* does not explicitly recommend a measure.

The *Handbook* provides detailed discussion of the various options to introduce quality measures for education, including on the basis of school inspections, class size, and standardized exam scores. The pros and cons of each are examined. Although imperfect, exam scores are preferred, as school inspections are subjective and not easily translated into quantities, and class size probably has a non-linear link to quality. The challenges of developing these indicators, which the *Handbook* wades through, are perhaps best captured by the following summary of how to improve education outcomes:

> "First, many of the traditional policies of simply providing more funds for schools or of not adding specific resources such as smaller classes do not provide much hope for significant improvement in student achievement. Second, a growing body of research shows that teacher quality is a primary driver of student achievement but that differences in quality are not closely related to teacher education and experience." (Hanushek and Woessmann, 2011:479).

An alternative approach to evaluate the quality of education output is to use subsequent earnings performance by students. However, this human-capital approach suggested by Jorgenson and Fraumeni (1992) has the drawback of reflecting not only the output of the education system, but also the effort of the individual student. It is thus rejected.[11] Perhaps a closer approximation to the value provided by an educational institution could be based on Ferrer and Riddell (2002) who look at the incremental value that credentials bring after controlling for years of education, although this value may also reflect the ability or dedication of the student to finish a program.

The third chapter examines how the approach outlined above can be implemented for education services in practice in international comparisons. The output measures chosen in the previous chapter play an important role in determining how informative the international comparisons are. There may be significant differences in pupil-hours across countries—the recommended output measure—depending on school hours and the length of holidays, which translates into larger differences in output across countries than if a simpler measure of number of pupils were used. Since a relatively simple measure of output is chosen, the third chapter is brief because these data are relatively readily available.

Quality differences across countries are likely to be greater than quality differences across time within a single country. Consequently, controlling for quality is critical in comparing country performance. This point is reinforced by Ferrer *et al.* (2006), who look at immigrant education and literacy in Canada. Among the factors that explain lower immigrant incomes in Canada, relative to the Canadian-born with the same education levels, is that the literacy skills of immigrants (as measured by the International Adult Literacy Survey) are lower than their foreign education might suggest. In other words, "differences in return to foreign versus Canadian acquired university education are entirely explained by foreign universities generating lower levels of (Canadian usable) literacy."

The *Handbook* moves rather quickly to the different international tests available to control for quality. The Programme for International Student Assessment (PISA) administers a test for between 4,500 and 100,000 pupils in each country for mathematics, reading and science. Alternative tests are the Progress in International Reading Literacy Study (PIRLS) and the Trends in International Mathematics and Science Study (TIMSS). The PISA test is preferred for quality adjustment in the *Handbook* on the basis that it covers a number of academic subjects, and is administered to 15-year-olds, which is more representative of secondary school populations. A shortcoming for time series analysis might be that the PISA test is only conducted every three years. At the moment there is no comparable test that could be used to compare quality of outcomes for tertiary institutions.

As mentioned previously, it may be difficult to determine what constitutes a desirable outcome of education and consequently, what quality

11 For discussion of these issues and the BEA experiments in measuring education output and outcomes, see Fraumeni *et al.* (2009).

Box 1 – An Example of Measuring Education Output

The methodology outlined in the *Handbook* is applied to expenditures per capita on secondary schooling across OECD countries in 2005. The traditional method of comparing inputs across OECD countries shows considerable variation in final expenditures per head on education. Countries such as Iceland, Israel and Australia put around twice as much input into education compared to Germany or Japan on a per capita basis. I take this to mean that the former countries have a combination of additional teachers and additional school supplies.

Using output volumes narrows these large cross-country differences. Those countries that had high inputs now have output that is only 50 per cent above the OECD average, which the *Handbook* argues is more plausible (without any reasoning given).

The ranking of some countries changes significantly depending on whether input or output measures are used: although Iceland ranks first whether input or output is used, Canada has the seventh highest input but only the 27th (out of 33 countries) highest output. Indeed, changing from input to output metrics lowers the implied contribution to education significantly for countries that spend heavily on education, such as Iceland, Australia, Sweden, Canada and Luxembourg.

Incorporating quality changes these rankings little. Quality adjusting this output raises Canada's ranking to 22nd. However, this ranking seems sensitive to the output measure chosen, as Canada ranks 29th in terms of the number of students as a share of its population (at around 19 per cent of the population). The highest ranked countries on the output measure—Iceland, Israel and Mexico—have around 30 per cent of their population in school. Since the output measure now simply reflects production, which is driven by the demographic structure of the population, there is not that much meaning to the ranking.

It would be interesting to examine additional metrics such as output per unit input, particularly over time. Now that the OECD is developing these output measures, the interpretation and data provided may change as well.

indicators should measure. One could well imagine that attaining a certain level of test results may be considered as short-sighted by those who value the education system as producing well-rounded individuals who can participate in society (e.g. Ravitch, 2012). Indeed, test scores may give undue weight to "academic" outcomes rather than to ensuring that individuals find occupations more suitable to their capacities, which in turn may be more vocational.

The *Handbook* provides experimental calculations using the proposed volume measures and quality adjustments (Box 1). Although the OECD cautions that the findings are preliminary, they show the potential for interesting results. The results merit greater discussion than the *Handbook* currently provides, including more discussion of how to interpret the data appropriately. It is interesting to learn that these output measures may be more reliable than the input data currently used, as there are quality problems when comparing wages and salaries across countries. Unfortunately, this point was not elaborated.

Measuring Health Output

The definition of healthcare that guides the analysis in the *Handbook* is the "treatment of a disease or medical services to prevent a disease". Clearly, there is wide heterogeneity in healthcare output as production is customized by individual. Nevertheless, the *Handbook* can take advantage of considerable administrative data that are available. It is at this stage that the OECD's consultations with specialists are shown to be valuable.

In implementing the definition of healthcare, the *Handbook* argues that the ideal output measure would be complete treatments of a disease. Looking at complete treatment means that the output measure should reflect the passage of an individual through different institutions providing healthcare services. For example, an output such as a complete hip replacement would include visiting a general practitioner, examination and operation by specialists at hospitals, and rehabilitation services. This description also shows how difficult implementing this measure would be since data systems do not currently track individuals across different institutions. This approach is also difficult to adopt in the case of chronic illnesses or in services such as caring for the elderly that have no clear end point on an annual basis.

As a result of challenges in looking at complete treatments, the *Handbook* recommends looking at episodes of treatment of particular diseases given by an institutional unit as the measure of health output. The common approach in medical institutions is to use Diagnosis Related Groups (DRGs). These are composite bundles of hospital services for which a hospital is, for example, given a single predetermined reimbursement from government or insurers. A typical DRG system consists of 500 to 1000 categories, each system different by country. A lengthy list of different output measures adopted in different countries is provided in the *Handbook*, which suggests the richness of potential indicators but also the challenges in ensuring comparability on an international basis.

There are problems with existing DRG data. The *Handbook* notes that there are some inconsistencies in the data, whereas data for national-accounts purposes would have to be relatively uniform over time. Smith and Street (2007) note concerns that DRGs do not incorporate technology change rapidly into their classification system.

The *Handbook* also makes recommendations for other health services. The output measure of institutions linked to chronic care may be limited to number of days of care provided. Other output measures are necessarily straightforward, such as the number of visits as a measure of output for general practitioners.

The *Handbook* argues that quality changes in the output of medical services cannot be made without some reference to the effects of medical services on outcomes. The outcome of healthcare is a state that consumers value, such as health status.[12] However, many factors will contribute to this outcome, including socioeconomic factors such as general economic conditions and inequality and poverty; individual behaviour such as exercise and diet; and environmental factors, such as the extent of pollution.

Assessing quality in healthcare would seem to be exceptionally difficult. Process quality depends on whether the right choices are made in treating the patient according to professional standards. To the extent that that is true, compliance rates with established procedures could be used as indicators, but there is insufficient data

12 Others may wish to incorporate other factors in quality measures, such as waiting time or the freedom of choice to choose one`s own physician or treatment.

on best practices at the moment. Other quality measures are country or institution-specific. The *Handbook* concludes that it is too difficult to recommend an explicit quality adjustment for health volume output at this time.

The *Handbook* undertakes preliminary analysis of international comparisons of healthcare, which again has the potential to be valuable work. Much has been written about differences across countries in healthcare systems and the markedly different shares of their national incomes that countries spend on healthcare. Nevertheless, international comparisons are currently made solely on total expenditures, or inputs. Developing output measures would necessitate a form of PPP conversion to ensure that comparisons of appropriate quantities are made. Spending more money as a share of GDP may be perfectly acceptable if more services are obtained, but less so if there is no commensurate increase in output.

One can well imagine the practical difficulties in data collection to shed light at these critical issues. The variety of healthcare outputs makes it difficult to identify a basket of health goods and services that can be compared across countries. There are differences in data gathering and definitions. Furthermore, institutional differences across countries may mean that there are a variety of incentives to supply varying quantities and qualities health services at different costs (and prices). In other words, the basket of healthcare goods and services might be endogenous to the institutional structure.

Despite these challenges, the *Handbook* presses ahead and looks at international comparisons of hospital services. These services constitute a large share of total healthcare costs and data are more readily available. The DRG approach is used as the basic unit of analysis with detailed descriptions provided of ideal data and 44 proposed case types (e.g. treatment of heart failure, normal delivery of babies, pneumonia, etc). Clearly, there has been much consultation on these recommendations as they are drawn from a variety of expert groups. Nevertheless, challenges are identified such as the absence of an internationally-comparable DRG system and incomplete coverage. Proposals are made to establish greater standardization in this area.

Concluding Remarks

The *Handbook* takes it as given that measuring output of education and health services is desirable. Having poor measures of output and productivity for such a large part of the economy will give misleading impressions of living standards, particularly as these services may become more important with an ageing population. Despite clear arguments in favour of developing output measures, it is fair to ask whether there are any drawbacks.

In principle, as mentioned in section two, a government's use of better measures of output should lead to better questions and decisions. However, in practice, it could also lead to poorer decision making as well. If exam scores were to be developed as the appropriate metric for quality improvement over time, then there could be an incentive to make exams easier. Ensuring international comparability of tests by using PISA would remain vital to avoid this possibility.

Incorporating volume output measures for education and healthcare services into the national accounts is a valuable initiative and will lead to better information on the aggregate allocation of resources. Such data will be particularly useful if they enable comparable international comparisons to be made so that lessons can be drawn on how to improve public services. This effort should also be extended to other non-market services, such as public administration. Clearly, the OECD can play a constructive role in ensuring progress on these fronts, although the usual plea with OECD documents for greater brevity and clarity also applies!

The *Handbook* provides a valuable summary of the state of play on measuring volume output of health and education services around the world. Although one may quibble with many details, it is clear that there is a large amount of painstaking work going on. Much work remains to be done on thorny methodological and data challenges.

However, I believe effort should be focused on adequately capturing the volume output of education and health services rather than their outcomes. As such, their estimation in the national accounts should reflect the cost of production rather than social valuations. Despite the desire to make the national accounts as comprehensive as possible, a degree of conservatism and prudence is necessary, and a modesty of expectations. Consequently, I would restrict attention to providing production metrics for health and education and therefore use costs as weights. As acknowledged by the *Handbook*, one has to be a bit wary of including quality measures.

Despite this caution, the importance of these industries and the wealth of data and analysis discussed in the *Handbook* suggest they should be a prime candidate for greater analysis in satellite accounts (Aizcorbe *et al.*, 2008).

References

ab Iorwerth, Aled (2006) "How to Measure Government Productivity: A Review Article on 'Measurement of Government Output and Productivity for the National Accounts' (The Atkinson Report)," *International Productivity Monitor*, No. 13, Fall, pp. 57-74. http://www.csls.ca/ipm/13/IPM-13-Iorwerth-e.pdf

Abraham Katharine G. and Christopher Mackie, eds. (2005) *Beyond the Market, Designing Nonmarket Accounts for the United States*, National Research Council of the National Academies (Washington, DC:, the National Academies Press.)

Aizcorbe, Ana, Carol Corrado and Mark Doms (2003) "When do Matched-Model and Hedonic Techniques Yield Similar Price Measures?" Federal Reserve Bank of San Francisco Working Paper 2003-14. http://www.frbsf.org/publications/economics/papers/2003/wp03-14bk.pdf

Aizcorbe, Ana, Bonnie A. Retus, and Shelly Smith (2008) "Toward a Health Care Satellite Account," *Survey of Current Business*, May, pp. 24-30. http://www.bea.gov/scb/pdf/2008/05%20May/0508_healthcare.pdf

Atkinson, Anthony (2005) *Atkinson Review: Final Report, Measurement of Government Output and Productivity for the National Accounts* (Norwich, U.K.: HMSO) available at http://www.ons.gov.uk/ons/guide-method/method-quality/specific/public-sector-methodology/atkinson-review/index.html.

Bureau of Economic Analysis (2011) "Chapter 9: Government Consumption Expenditures and Gross Investment: Updated November 2011," (Washington, D.C.: Bureau of Economic Analysis). Available at: http://www.bea.gov/national/pdf/ch9%20govt%20ce&GI%20for%20posting.pdf

Commission on the Reform of Ontario's Public Services (2012) "Public Services for Ontarians: A Path to Sustainability and Excellence," (Toronto: Government of Ontario). www.fin.gov.on.ca/en/reformcommission/

Deveci, Nursen, Heurlén, Kamilla and Sørensen, Henrik Sejerbo (2008) "Non-Market Health Care Service in Denmark – Empirical Studies of A, B and C Methods," paper presented at the 30th General Conference of the International Association for Research in Income and Wealth, Portoroz, Slovenia. http://www.iariw.org/papers/2008/heurlen.pdf

Diewert, W. Erwin (2008) "The Measurement of Nonmarket Sector Outputs and Inputs Using Cost Weights," *mimeo*, University of British Columbia. Available at: http://www.nber.org/public_html/confer/2008/si2008/PRCR/diewert.pdf

Diewert, W. Erwin (2010) "Measuring Productivity in the Public Sector: Some Conceptual Problems," *mimeo*, University of British Columbia. Available at: http://faculty.arts.ubc.ca/ediewert/dp1004.pdf

The Economist (2012) "Shopping around for Surgery: Companies Try to Make Health-care Costs Transparent," February 4.

Fabricant, Solomon and Robert E. Lipsey (1952) "Productivity in Government and the Output of Government Services," in *The Trend of Government Activity in the United States Since 1900*, Solomon Fabricant and Robert E. Lipsey (eds.) (New York: National Bureau of Economic Research), pp. 84-111.

Ferrer, Ana, David A. Green, and Craig W. Riddell (2002) "The Role of Credentials in the Canadian

Labour Market," *Canadian Journal of Economics* Vol. 35, No. 4, pp. 879-905.

Ferrer, Ana, Green, David A. and Riddell, W. Craig (2006) "The Effect of Literacy on Immigrant Earning," *Journal of Human Resources* Vol. 41, No. 2, March, pp. 380-410.

Fraumeni, Barbara M., Marshall Resinsdorf, Marshall, Brooks B. Robinson, and Msatthew P. Williams (2009) "Price and Real Output Measures for the Education Function of Government," in *Price Index Concepts and Measurement*, W. Erwin Diewert, John S. Greenlees. and Charles R. Hulten (eds.) (Chicago: University of Chicago Press), pp. 373-403.

Gu, Wulong and Ambrose Wong (2010) "Investment in Human Capital and the Output of the Education Sector in Canada," paper presented at the 31st General Conference of the International Association for Research in Income and Wealth. St-Gallen, Switzerland. http://www.iariw.org/papers/2010/poster1Gu.pdf

Hall, Robert E. and Charles I. Jones (2007) "The Value of Life and the Rise in Health Spending," *Quarterly Journal of Economics*, Vol. 122, No. 1, February, pp. 39-72.

Hanushek, Eric A. and Ludger Woessman (2011) "Educational Outcomes," *Economic Policy*, July, pp. 427-491.

Heikkinen, Jani and Sami Hautakangas (2008) "Outcome and National Accounts", paper presented at the 30th General Conference of the International Association for Research in Income and Wealth, Portoroz, Slovenia. Available at: http://www.iariw.org/papers/2008/heikkinen.pdf

Jorgenson, Dale W. and Barbara M. Fraumeni (1992) "The Output of the Education Sector," in *Output Measures in the Service Sector*, Studies in Income and Wealth, Vol. 56, , Z. Griliches, (ed.), (Chicago: University of Chicago Press), pp. 303-343.

Murray, Richard (2005) "A Review of the Atkinson Review," Swedish Network for European Studies in Economics and Business. Available at: http://www.snee.org/filer/papers/329.pdf

OECD (2007) "Towards Measuring Education and Health Volume Output: An OECD Handbook," Working Party on National Accounts (Paris: OECD).

OECD (2011a) *Education at a Glance, 2011* (Paris: OECD).

OECD (2011b) "OECD Health Data 2011 – Frequently Requested Data," (Paris: OECD)

Ravitch, Diane (2012) "Schools We Can Envy," *New York Review of Books*, Vol. 59, No. 4, March, pp. 19-20.

Schreyer, Paul (2010) "Towards Measuring the Volume Output of Education and Health Services: A Handbook," OECD Statistics Directorate Working Paper 2010/02, (Paris: OECD) http://www.oecd.org/LongAbstract/0,3425,en_2649_33715_45115957_1_1_1_1,00.html

Smith, Peter C. and Andrew Street (2007) "The Measurement of Non-Market Output in Education and Health," *Economic and Labour Market Review*, Vol. 1, No. 6, June, pp. 46-52.

Stiglitz, Joseph E., Amartya Sen, and Jean-Paul Fitoussi (2009) *Report by the Commission on the Measurement of Economic Performance and Social Progress* (Paris: Commission on the Measurement of Economic Performance and Social Progress) Available at: http://www.stiglitz-sen-fitoussi.fr/en/index.htm.

Trewin, Dennis (2004) "Measurement of Services: Recent ABS Experience,", *Statistical Journal of the United Nations*, Vol. 21, No. 3-4, pp. 277-290.

Wang, J. Christina, Susanto Basu and John G. Fernald (2009) "A General-Equilibrium Asset-Pricing Approach to the Measurement of Nominal and Real Bank Output," in *Price Index Concepts and Measurement*, W. Erwin Diewert, John S. Greenlees, and Charles R. Hulten, eds. (Chicago: University of Chicago Press), pp. 273-320.