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Living standards in an ageing, greener, knowledge economy

Towards a period of lean cows?

Jorgen Mortensen*

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* Associate Senior Research Fellow, Centre for European Policy Studies

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Abstract

This paper provides evidence on past growth of productivity, analysing the evolution of labour productivity, capital deepening and multi-factor productivity. Reviewing recent studies it shows that more and more of economic growth is attributable to the accumulation of intangible capital and that consequently, an increasing share of conventionally measured rise in labour productivity has, in fact, been ploughed back into the economy as intangible capital formation. In addition, it shows that on average for the developed countries examined, the growth of total factor productivity has been the main determinant of the increase in living standards over the 50 years from 1960 to 2010. It also demonstrates a striking slowdown in the growth of both productivity and living standards during this period. Looking ahead, it argues that the period 2010 to 2030 is likely to see a considerable expansion of tangible and intangible capital formation and lower growth of multi-factor productivity. The paper therefore concludes that over the next 20 years the scope for growth in living standards in the developed economies will be very limited, on average around half a percent per annum, with serious consequences for social conditions and a likely aggravation of inequalities.

* Jorgen Mortensen is Associate Senior Research Fellow at CEPS.

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Introduction

For a long time, 'productivity' was defined in a common sense, simplistic approach as output per unit of labour input. In the public domain the problems of measuring output and labour input were and are still largely considered issues too complex to be debated in the 'forum' but several decades ago professional economists and statisticians had already embarked on a heated debate concerning the gauging of the volume of output and, somewhat later, the input of labour. At least in economic analysis the measurement of productivity is nowadays based on the concept of multi-factor or total factor productivity, which takes account of the input of capital services along with the traditional labour services.

In addition, in the modern knowledge society more and more of capital formation is actually of an immaterial nature. The strong increase in the share of services in the economy has had, as its counterpart, a decline in the share of conventional goods-producing industries. As a consequence of the increase in the share of intangible investment in the economy, fewer resources are available for an increase in consumption as conventionally measured.

The level and growth of consumption is determined by 'real disposable income', which in turn is determined by incomes, taxes and inflation, with the latter determined essentially by productivity and, in an open economy, terms of trade.

This statement is formally rather trivial but in reality the measurement of inflation and of changes in incomes, productivity and terms of trade each raises enormous methodological difficulties. Indeed, significant amounts of time are spent in research departments of statistical institutes and international gatherings to clarify these issues and to arrive at a consensus allowing domestic policy analysis and international comparative studies to be undertaken on a reasonably sound basis.

The measurement of inflation 'when it is not business as usual' poses the key problem of choosing the weighting scheme when the structure of demand is changing substantially, as discussed in a recent CEPS paper.[1] Although the splitting of any nominal increase between price and volume change has implications for the measurement of both volume and price changes, there are also intrinsic issues raised by the measurement of the volume increases. While it is good to keep the problems of measuring inflation in the back of the mind, the present paper deals with the specific issues of measuring productivity and, based on the review of these issues, presents an assessment of the prospects for productivity changes and thus for the potential changes in the standard of living of consumers over the coming decades.

Productivity growth in the distant and recent past

The classical productivity concepts

Classical economic theory, on which much of current economic theory remains founded, considered essentially three factors of production – land, labour and capital. Each of those had its own dimension: land was a stock, labour a flow (input) and capital was money capital in the form of a stock of capital goods. The concept of capital as an 'advance' of money was taken to its extreme by Böhm-Bawerk, who coined the notion of "*umwegsproduktion*".[2]

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[1] J. Mortensen and C. Frale, *The challenge of measuring inflation when business is* not *as usual*, CEPS Working Document No. 306, Centre for European Policy Studies, Brussels, October 2008 (http://www.ceps.eu/book/challenge-measuring-inflation).

[2] See for example, E. von Böhm-Bawerk, *Positive Theory of Capital*, London: Macmillan, 1891.

The view of the stock of capital as an advance of money was rejected by Clark,[3] arguing that (fixed) capital was a factor of production on equal footing with land and labour. Yet the distinction between monetary capital and fixed capital has throughout the history of economic analysis been blurred by the fact that at the macroeconomic level, the stock of fixed capital unavoidably must be expressed as an aggregate in monetary terms, that is, as a 'value'.

In the early stages of economic analysis, 'productivity' was defined in a common sense, simplistic approach as output per unit of labour input, measured as number of persons employed or, alternatively, in terms of number of hours worked. In the public domain the problems of measuring output and labour input were and are still largely deemed issues too complex to be debated in the 'forum' but several decades ago professional economists and statisticians had already embarked on a heated debate concerning the gauging of the volume of output and, somewhat later, the input of labour.

In fact, speculations concerning the measurement of the volume of output emerged already at the birth of national accounting in the 1920s, as the statisticians realised that the calculation of 'volumes' in a complex economic system was equivalent to adding apples and strawberries. For each well-defined basic commodity the definition of volume and price was thought to be relatively straightforward. But for a basket of commodities, it could only be done by some kind of weighting scheme, based for example on the 'values' of each unit of apples and strawberries at a given point in time. Hence the only way of measuring a 'volume' of a complex basket of goods (and services) is, first to translate the basket of commodities into a basket of monies and then to examine the splitting of this monetary basket into a measure of volume and price. Thus, as already underlined above, the definition of a 'volume' of output is actually the other side of the coin of the estimate of price changes and therefore equivalent to the splitting of a nominal value into volume and inflation.

More recently additional problems of measuring quality and the associated price changes (for example with respect to ICT) have been added to the already long list of causes of headaches for the statisticians but this extremely serious complication will only be mentioned in passing and not further explored in the present paper.

In addition to the huge problems of gauging the volumes of output, consumption, investment and foreign trade in the economy, the compilation of output per unit of labour input also needs to face up to the challenge of measuring labour 'input'.[4] The measurement of 'input' of labour in terms of hours or number of workers was for a long time accepted intuitively as the relevant statistic. Still, the pooling together of man years of an unskilled youngster and an engineer with a diploma from a leading institute of technology and several decades of professional experience, from the point of view of economic analysis, does not make more sense than to add, say, a kilogramme of pears and a kilogramme of apples together in one set.[5] Accordingly, there is a case for some kind of weighting scheme equivalent to transforming an aggregate expressed in working time (hours, years or full-time equivalents) into a 'basket' of working time of different categories of workers, or indeed a monetary aggregate of 'labour services'.

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[3] J.B. Clark, "Concerning the Nature of Capital: A Reply", *Quarterly Journal of Economics*, May 1907, pp. 526-53.

[4] A more correct terminology would be 'labour services' so as to distinguish this clearly from the input of intermediary goods and services.

[5] See, notably, contributions by Dale Jorgensen, who again and again has stressed the need to take account of changes in the 'quality' of labour, that is, of the level of educational attainment of the labour force.

As an alternative to considering the determination of productivity mainly from the side of labour, the path-breaking Harrod-Domar model saw output as being mostly determined by the amount of capital utilised in the production process and introduced the 'capital/output ratio' as the key constant in economic growth. Notably, however, the measurement of the 'stock of capital' posed statistical problems even more complicated than the measurement of output and labour input.

A natural step involved, not surprisingly, taking account of both capital and labour in a 'production function' that includes both capital and labour and allows for substitution between these two factors of production. A formalised version of such a function was presented in 1928 in an article by Cobb and Douglas.[6] Subsequently the implications and limitations of this approach were made evident and a series of alternatives proposed by a number of researchers. The later 'neo-classical growth model' (formulated initially by Robert Solow) indeed dropped the assumption of a linear relation between fixed capital and output by introducing the input of labour explicitly into the production function with a scope for substitution between capital and labour (measured in hours or man years). Nevertheless, the analysis of the relation between factor use and output has been a stable of economic analysis for the whole post-war period, with the development of a branch of quantitative analysis of the growth process commonly known as 'growth accounting'.

An important result of the growth accounting discipline has been that even taking account of both labour and capital input leaves a residual of 'productivity', which, to underline the fact that the definition of 'input' had been broadened to incorporate two factors, was termed 'total factor productivity'. By a non-specialist this can best be understood as an average of labour and capital productivity. The introduction of this broader concept of productivity at first met some resistance, for example within the European Commission where a paper prepared in 1984 presenting some first estimates of this productivity concept did not obtain unanimous support but was nevertheless published with some cuts.[7]

Analysis of productivity issues often takes as the point of departure developments in the US, which, as the leading economy during the last century, has been held to be on the productivity frontier, with other economies tending to follow and catch up with more or less luck. The history of productivity developments in the US is therefore likely to throw light on later development in other countries. According to estimates prepared by a leading specialist in economic history, Angus Maddison,[8] the growth in labour productivity in the US accelerated during most of the 20th century, from some 2% per annum during the period 1870–1913 to 2.5% from 1913 to 1950. Yet a large part of this apparent acceleration of the growth in productivity was attributable to a pronounced increase in the ratio of fixed capital to output (capital deepening) from an estimated level of 1.71 in 1870 to as much as 3.39 in 1913. Consequently, total factor productivity during the 1870–1913 period increased by only 0.36% per annum. During these four decades most of the increase in production was thus ploughed back into the economy, with only a modest margin for an increase in living standards.

The 'sacrifice' of living standards during the late 19th and early 20th centuries was compensated during the subsequent decades, as the process of capital deepening was reversed and total factor productivity accelerated substantially. The period from 1913 to 1973 (despite the 1930 depression and the Second World War) was a 'golden age' with sizeable scope for

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[6] C.W. Cobb and P.H. Douglas, "A Theory of Production", *American Economic Review*, March 1928.

[7] J. Mortensen, *Profitability, relative factor prices and capital/labour substitution in the Community, the United States and Japan 1960-1983*, European Economy No. 20, European Commission, Brussels, 1984.

[8] A. Maddison, *Contours of the world economy, 1-2030 AD*, Oxford: Oxford University Press, 2007.

an increase in living standards. During the next 30 years, however, from 1973 to 2003, total factor productivity growth according to Maddison's estimates (and which are corroborated by official statistics) slowed down to a meagre annual rate of 0.65%, or only marginally above the rate experienced from 1870 to 1913 (Table 1).

Another striking feature of productivity developments during the late 19th and 20th centuries is the counterpart of the swings in total factor productivity growth: the effect of capital deepening.

As shown in Table 1, during the period 1820–70, labour productivity growth was fully, indeed more than, attributable to capital deepening (1.25 points per year). During the following 43 years the rate of capital deepening was even higher, accounting for 1.57 points of labour productivity growth. Then, during the rest of the 20th century, the productivity contribution from capital deepening in the US oscillated at around 1 percentage point.

Table 1. Capital/output ratios and productivity, US

	1820	**1870**	**1913**	**1950**	**1973**	**2003**
Capital/output ratio	0.94	1.71	3.29	2.44	2.10	2.34
Machinery and equipment	0.07	0.20	0.52	0.64	0.64	1.11
Non-residential structures	0.87	1.51	2.77	1.80	1.46	1.23
Productivity (% change)		1820–1870	1870–1913	1913–1950	1950–1973	1973–2003
Labour productivity	–	1.10	1.93	2.47	2.77	1.66
Total factor productivity	–	-0.15	0.36	1.62	1.75	0.65
Effect of capital deepening	–	1.25	1.57	0.85	1.02	1.01

Source: Maddison (2007).

An analysis of the more recent evolution of the development of labour productivity in the old EU member states (EU-15) and four important non-EU OECD countries (the US, Canada, Japan and Norway) shows a pronounced slowdown in the rate of productivity growth during the 50 years from 1960 to 2010. In fact, on average for these 19 countries, the rate of growth of labour productivity, weighted by the mid-period population, slowed down from 4.7% during the 1960s, to 2.4% in the 1970s and 1.9% in the 1980s and further to 1.7% in the 1990s. For the period 2000 to 2010 the productivity growth rate fell to 1.2%, to a large extent as a result of the 2007–09 recession, and thus not necessarily as the expression of a more fundamental change in the longer-term tendency (Table 2).

For individual countries and periods, there were little changes in labour productivity disparities. However, not all countries experienced the same degree of recession in the 2000–10 decade, resulting in some increase in the coefficient of variation, from around 0.3 points during the period from 1990 to 2000 to 0.5 percentage points during the last decade (Table 2).

Despite the relatively small disparity with respect to productivity growth, in reality countries with a relatively low level of per capita GDP in 1960 experienced a much higher degree of capital deepening than countries with a high level of GDP in this starting position.

As shown in Figure 1, the contribution of capital deepening to the growth of labour productivity during 1960–2010 varied from 1.2-1.4 percentage points for the countries with the lowest level of per capita GDP to as little as 0.5 percentage points for the country with the

highest level of per capita GDP (US). As should be expected, countries with a low level of output per capita in the starting position had to plough much more of the growth of output back into the economy in the form of investment in fixed capital.

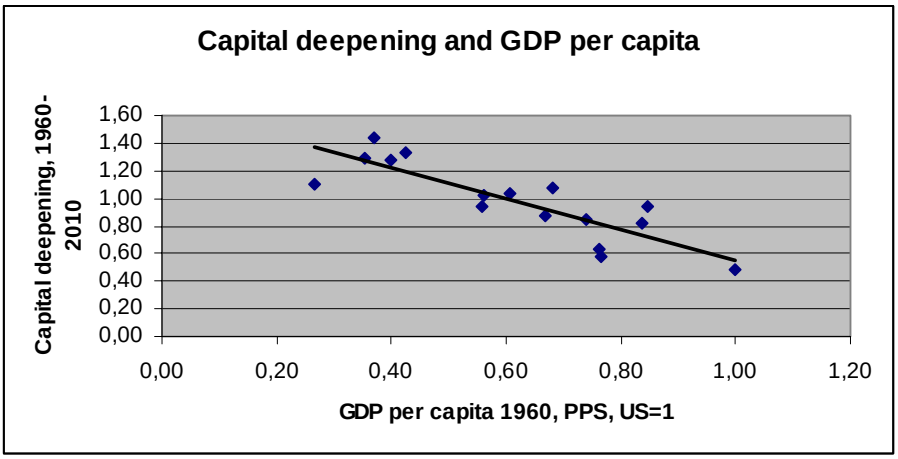
On average for the 50 years and the countries included here, capital deepening amounted to 0.8 percentage points, but with a higher level (some 1.2 points) during the first two decades and some 0.6-0.7 points from 1980 to 2010.

Table 2. Labour productivity growth (% per annum)

	1960–2010	**1960–70**	**1970–80**	**1980–90**	**1990–2000**	**2000–10**
Belgium	2.3	4.4	3.2	1.8	1.6	0.6
Denmark	2.0	3.5	1.9	1.7	2.2	0.6
West Germany	2.3	4.2	2.6	1.3	2.5	0.7
Ireland	3.4	4.2	3.8	3.8	3.3	1.7
Greece	3.3	9.4	4.0	-0.3	1.8	1.9
Spain	3.0	6.7	4.2	1.9	1.1	1.1
France	2.6	5.3	3.2	2.1	1.6	0.7
Italy	2.5	6.2	2.8	1.8	1.6	-0.1
Luxembourg	1.8	2.9	1.4	3.3	1.6	-0.1
Netherlands	2.1	3.9	2.6	1.7	1.5	1.1
Austria	2.6	5.1	2.9	2.0	2.0	0.9
Portugal	3.4	5.6	4.9	3.5	2.2	0.6
Finland	2.9	4.4	3.6	2.5	2.9	1.2
Sweden	2.1	3.9	1.2	1.5	2.6	1.3
UK	1.9	2.5	1.7	2.0	2.3	1.0
Norway	2.4	3.5	3.4	2.0	2.6	0.7
US	1.7	2.3	1.2	1.4	1.8	1.8
Japan	3.6	8.6	3.7	3.7	1.0	1.1
Canada	1.3	2.4	1.2	0.9	1.7	0.4
Average	2.5	4.7	2.8	2.0	2.0	0.9
Average, weighted	2.3	4.6	2.4	1.9	1.7	1.2
Standard deviation	0.6	2.0	1.1	1.0	0.6	0.5
Coefficient of variation	0.3	0.4	0.5	0.5	0.3	0.5

Source: AMECO database (European Commission, DG for Economic and Financial Affairs).

Figure 1. Capital deepening 1960–2010 and GDP per capita 1960



Trendline: 1.66-1.11*PerCapitaGDP
Sources: AMECO database (European Commission, DG for Economic and Financial Affairs) and own calculations.

Table 3. Total factor productivity (% change)

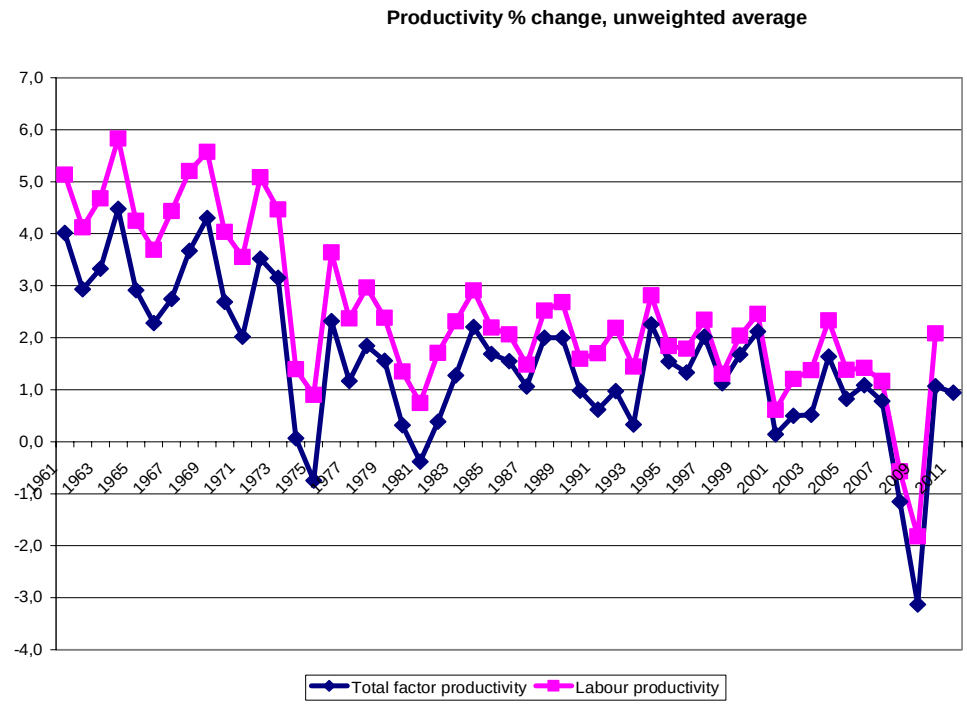
	1960–2010	1960–70	1970–80	1980–90	1990–2000	2000–10
Belgium	1.4	3.2	1.9	1.1	0.9	0.1
Denmark	1.3	2.9	0.9	1.1	1.8	0.0
West Germany	1.3	2.5	1.5	1.0	1.4	0.3
Ireland	2.0	2.3	1.9	2.4	3.4	0.2
Greece	1.9	6.0	1.8	-0.8	1.2	1.4
Spain	1.7	5.2	2.0	1.1	0.4	-0.1
France	1.5	3.6	1.7	1.3	0.9	0.1
Italy	1.5	4.3	1.8	1.0	1.0	-0.5
Luxembourg	1.3	2.4	1.0	2.9	1.2	-1.2
Netherlands	1.3	2.5	1.3	1.1	1.2	0.3
Austria	1.5	3.5	1.5	1.1	1.1	0.4
Portugal	2.3	5.0	3.2	2.1	1.1	-0.2
Finland	1.9	2.8	2.1	1.5	2.3	0.8
Sweden	1.3	2.6	0.3	0.8	1.8	0.9
UK	1.3	1.7	1.1	1.7	1.7	0.4
Norway	1.4	1.8	1.8	1.0	2.4	0.0
US	1.2	1.9	0.9	1.1	1.3	0.7
Japan	2.3	7.0	1.5	2.4	0.1	0.7
Canada	0.9	2.1	0.8	0.4	1.3	-0.3
Average	1.6	3.3	1.5	1.3	1.4	0.2
Average weighted	1.5	3.4	1.3	1.3	1.1	0.4
Standard deviation	0.4	1.5	0.6	0.8	0.7	0.6
Coefficient of variation	0.3	0.4	0.5	0.6	0.7	1.4

Source: AMECO database (European Commission, DG for Economic and Financial Affairs).

As shown in Figure 1 countries with a comparatively low level of per capita GDP, in order to reduce the productivity gap vis-à-vis the more prosperous countries, are obliged to undertake a higher rate of capital deepening. Consequently, countries such as Ireland, Greece and Portugal during the period 1960 to 2010 experienced a larger gap between the conventionally measured labour productivity and multi-factor productivity. This feature of the economic growth process is illustrated by the smaller standard deviation of the growth rates of the latter, 0.4 (see Table 3) as compared to 0.6 for the conventionally measured labour productivity.

As illustrated in Figure 2, the growth of total factor productivity up to 2007 was rather well in line with the trends during the preceding two decades and the slow growth measured on average during the decade 2000–10 is mainly attributable to the effects of the recession. But some of the increase during the period up to 2007 may be attributable to the financial bubble and the resulting particular boost in demand. Nevertheless, on the whole this effect may have been of minor importance and not have constituted a significant break in the relatively stable trend rate of productivity growth of some 1% per annum on average for these 19 countries since 1980, following the deceleration from 1960 to 1980.

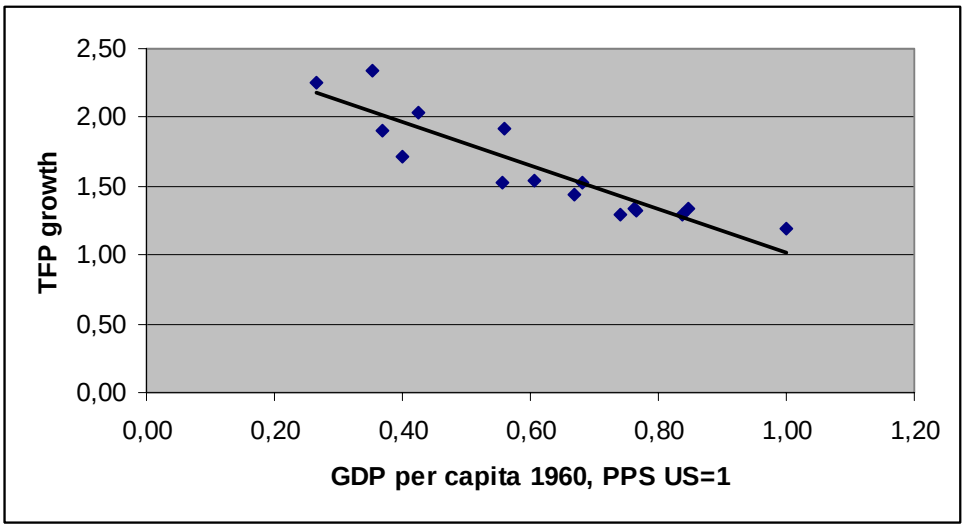
Figure 2. Growth of productivity, 19 countries (annual % change)



Source: AMECO database (European Commission, DG for Economic and Financial Affairs).

Given the tendency for capital deepening to be higher the lower the level of GDP per capita relative to that of the US, low per-capita countries have to plough back more of the increase in labour productivity and therefore have a much smaller increase in total factor productivity. As illustrated in Figure 3, the trend line, expressing the correlation between GDP per capita in the initial position (1960) and the growth of total factor productivity during the following 50 years, is therefore steeper than a line showing the corresponding correlation between per capita GDP and labour productivity.

Figure 3. Per capita GDP and total factor productivity



Trendline: 2.59-1.57*PerCapitaGDP

Sources: AMECO database (European Commission, DG for Economic and Financial Affairs) and own calculations.

The rising share of intangibles in the economy

J.W. Kendrick,[9] in providing the first estimates of the total amount of "intangible" investment in the US during the 20th century, already shows a pronounced increase through time, reflecting in particular the important rise in resources devoted to education, training and research and development (R&D). The rise in intangible investment has translated into a substantial rise in the stock of intangible capital. Furthermore, during the first half of the 20th century the relative prices of conventional, tangible capital goods – at least those that have been used as deflators to create constant-price estimates of the capital stock – rose more rapidly than the prices of consumer goods and real wages. This, and the shorter and shortening service lives of tangible reproducible assets, especially in comparison with the assumed longevity of educational and training investment embodied in the labour force, have also contributed to the differentially rapid growth of the intangible component of the total capital stock.[10]

The estimates prepared by Kendrick and reproduced by Abramovitz and David[11] and reordered somewhat by the author (presented in Table 4), show that the share of conventional tangible capital in the total stock of capital in the US economy fell from 65% in 1929 to 46.5% in 1990. Correspondingly, the share of non-conventional, non-tangible capital rose from some 35% in 1929 to 53.5% in 1990 and by the latter year the total estimated value of immaterial capital was thus higher than that of tangible fixed capital.

[9] J.W. Kendrick, "Total Capital and Economic Growth", *Atlantic Economic Journal*, Vol. 22, No. 1, 1994.

[10] See M. Abramovitz and P.A. David, "Technological Change and the Rise of Intangible Investments: The US Economy's Growth-Path in the Twentieth Century", in *Employment and Growth in the Knowledge-based Economy*, OECD, Paris, 1996, p. 41.

[11] For the reference see the source for Table 4.

Table 4. Capital stock and capital/output ratio in the US, 1929–90

	1929	1948	1973	1990
Share of total capital stock, %				
Conventional tangible capital	65.1	57.8	50.2	46.5
Non-conventional, non-tangible capital	34.9	42.2	49.8	53.5
Capital/GDP ratio				
Conventional capital/GDP	7.39	6.25	5.35	5.85
Intangible capital/GDP	3.95	4.57	5.30	6.73
Total capital stock/GDP	11.35	10.82	10.65	12.58

Sources: J.W. Kendrick, "Total Capital and Economic Growth", as quoted in M. Abramovitz and P.A. David (1996), op. cit. Calculations by the author.

A striking conclusion emerging from these estimates is the sharp decline in the conventionally defined capital/output ratio from 7.4 in 1929 to 5.9 in 1990. Still, the decline was largely compensated by a pronounced rise in the ratio of intangible capital to GDP, from about 4 in 1929 to 6.7 in 1990. The overall capital/output ratio consequently declined only moderately from 1929 to 1948 and even less from 1948 to 1973. In addition, since 1973 the conventionally defined capital/output ratio increased somewhat while the ratio of intangible capital to output rose strongly, resulting in a steep rise in the overall capital/output ratio, to a level preceding that of 1929.

Although the estimates compiled by other researchers may differ somewhat from those presented above, the broad conclusions in most cases are consistent with Kendrick's results: in the most advanced industrial economy, the US, the economic weight and impact of intellectual capital now exceeds that of tangible capital. Furthermore, even the conventional hardware incorporates an increasing amount of (embedded) intangible goods, such as embodied software notably in robots and other automatic equipment..

These findings shed new light on a policy issue that was a concern for policy-makers on both sides of the Atlantic during the 1970s and 1980s: the decline in fixed capital formation in proportion to GDP. Notably, in a context of the emerging 'knowledge economy' and changes in the nature of competition, enterprises have not reduced overall capital formation but rather shifted more and more resources into investment in intangibles. Since investment in intangibles from the point of view of accounting normally was not considered 'capital formation', this change in the behaviour of firms and managers went unnoticed by academics and policy-makers for a long time, which in certain countries and periods possibly resulted in failures and mistakes in the design of economic policy.

The progressive acceptance, at least among professional economists, of total factor productivity as a more appropriate measure of productivity than the simpler concept of labour productivity still has not completely eliminated all remaining problems of assessing the 'benefits' of the production process. In the 1990s, accountants, statisticians and economists already realised that output was obtained not only by combining machinery, land and man-hours, but also by adding the know-how, skills and organisation of the whole sequence of production from concept, through processing, to production and commercialisation. The fact that output, in reality, is obtained by bringing together labour and fixed (tangible) capital with an 'immaterial' or 'intangible' (invisible) production factor was not reflected in the business

or national accounts. For a long time they were constructed according to the traditional paradigms concerning the production process, which ignored a large amount of the spending on these immaterial aspects of the process.

The debate concerning the scope for showing more explicitly, even if not completely, these immaterial aspects of production in business accounting is still going on and is, it seems, unlikely to lead to a complete revolution of the classical accounting concepts. More recently, however, attempts have been made by economic analysts to bring together as many indicators as possible, and on that broader basis to assess the full contribution of these intangibles to the level of and change in output.

As a consequence of these successive innovations of the productivity concept, what was originally interpreted as an increase if "efficiency" has in fact been obtained through an increase in the ratio between the total of tangible and intangible capital to output. Thus, as ever more of the capital stock takes the form of intangible assets, the *umwegsproduktion* has been progressively more comprehensive, with the result that less and less of output has been available for current consumption.

A large step in the analysis of the effect of intangibles on economic growth was made by Corrado, Hulten and Sichel in 2005, presented in a Federal Reserve Board working paper in 2006.[12] In addition to analysing the effect of investment in both tangible and intangible assets on the growth of productivity, they also take account of the potential effect on productivity of the rise in the human capital endowment of the labour force resulting from the change in the average level of educational attainment of the working population. As shown in Table 5, they estimate total factor productivity growth from 1973 to 1995 of 0.66%, or close to Maddison's (2007) estimate for the entire period 1973–2003. But more than a third of this increase is attributable to a change in the composition (educational attainment) of the labour force, leaving an even smaller margin for a genuine increase in living standards: 0.41%. They find a somewhat higher rate of growth of multi-factor productivity for the period 1995–2003 but do not assess the extent to which this may be attributable to cyclical swings in output and employment.

The work by Corrado, Hulten and Sichel was followed up by Marrano and Haskel[13] for the UK and presented in a working paper in 2006. The latter authors find that the UK private sector spent about 10% of GDP on investment in intangibles in 2004, an amount equal to the investment in tangible assets. These results are also broadly consistent with estimates presented in a European Investment Bank (EIB) paper from 2009.[14] Research is now underway in two research projects sponsored by the EU's research programme, INNODRIVE and COINVEST, to estimate the contribution of intangibles to growth in selected EU countries.

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[12] C. Corrado, C. Hulten and D. Sichel, *The Contribution of Intangible Investments to US Economic Growth: A Sources-of-growth Analysis*, NBER Working Paper No. 11948, National Bureau of Economic Research, New York, NY, 2006 (also published as *Intangible Capital and Economic Growth*, Staff Working Paper in Finance and Economics, No. 2006-24, Federal Reserve Board, Washington, D.C., April).

[13] M.G. Marrano and J. Haskel, *How much does the UK invest in intangible assets?*, Working Paper No. 578, Queen Mary, University of London, November 2006.

[14] B. Van Ark, J. Hao, C. Corrado and C. Hulten, "Measuring intangible capital and its contribution to economic growth in Europe", *EIB Papers*, Vol. 14, No. 1, European Investment Bank, Luxembourg, 2009.

Table 5. Total factor productivity including intangibles, US (percentage change and percentage points, non-farm business sector)

	1973–95	1995–2003	Change
Labour productivity (per hour worked)	1.63	3.09	1.45
Capital deepening	0.97	1.68	0.71
Tangibles	0.55	0.85	0.30
Intangibles	0.43	0.84	0.41
Labour composition	0.25	0.33	0.08
Multi-factor productivity, including intangibles	0.41	1.08	0.67

Source: Corrado, Hulten and Sichel (2006).

Initial estimates prepared by the INNODRIVE team are well in line and consistent with the estimates by Corrado, Hulten and Sichel (2006) for the US and Marrano and Haskel (2006) for the UK. Notably, as shown in Table 6, for the nine countries so far included[15] for the period 1995–2005 labour productivity increased by 2.07%. Yet, the effect on labour productivity of capital deepening, including investment in intangibles, accounted for on average (unweighted) 1.07 percentage points, of which 0.22 points are attributable to intangible assets that are not so far capitalised in the national accounts. Consequently, total factor productivity growth, including the influence of intangibles, amounted to only 0.98%. The breakdown of this ten-year period into two sub-periods, 1995–2000 and 2000–05, shows a pronounced slowdown of total factor productivity growth from 1.62% in the first period to only 0.46% in the second period, presumably owing to the effects of the cyclical downturn (the bursting of the ICT bubble) after the year 2000.

It should be noted, however, that the INNODRIVE estimates do not include estimates of the effect of a change in the composition of the labour force, which, according to Corrado, Hulten and Sichel accounted for 0.25 and 0.33 percentage points in the US in the periods 1973–95 and 1995–2003 respectively. Given that in most EU countries the level of educational attainment is still rising towards the level in the US, the effect of this component in EU countries can be assumed to have been significantly stronger than in the US, perhaps in the range of 0.5 percentage points.

The order of magnitude of the INNODRIVE estimates of total factor productivity for Germany, Italy, Austria and Denmark are consistent with the estimates prepared by Van Ark et al. (2009) in the EIB paper referred to above. This latter paper also emphasises that intangible investment is highly correlated with the level of GDP per capita and that there are clear signs of a 'trade off' between tangible and intangible investment, with the latter rising with per capita GDP as a share of total capital formation.

[15] These are Austria, Denmark, Finland, Germany, Italy, the Netherlands, Portugal, Sweden and the UK.

Table 6. INNODRIVE estimates of the growth of productivity and effect of intangibles

(% change per annum on average)

	1995–2005				1995–2000				2000–05			
	LPG	**NA-CD**	**NI-CD**	**TPF**	**LPG**	**NA-CD**	**NI-CD**	**TPF**	**LPG**	**NA-CD**	**NI-CD**	**TPF**
AT	2.05	0.83	0.26	0.95	3.14	0.91	0.29	1.92	1.36	0.85	0.25	0.26
DK	1.38	0.45	0.20	0.73	0.86	-0.18	0.17	0.87	1.77	1.04	0.22	0.50
FI	2.83	0.35	0.32	2.14	3.39	-0.16	0.36	3.19	2.59	0.88	0.28	1.41
DE	2.13	1.10	0.21	0.82	2.22	0.95	0.19	1.07	1.92	1.09	0.22	0.59
IT	0.23	0.42	0.05	-0.24	1.08	0.34	0.12	0.61	-0.19	0.54	-0.01	-0.72
NL	2.16	0.71	0.16	1.28	2.75	0.40	0.25	2.09	1.92	1.14	0.11	0.66
PT	1.93	1.92	0.23	-0.22	2.93	1.94	0.22	0.75	0.70	1.89	0.25	-1.42
SE	3.36	0.98	0.36	1.99	3.55	0.69	0.38	2.45	3.49	1.19	0.33	1.94
UK	2.53	0.92	0.23	1.36	2.87	0.88	0.34	1.63	2.07	0.98	0.14	0.94
AV	2.07	0.85	0.22	0.98	2.53	0.64	0.26	1.62	1.74	1.07	0.20	0.46

LPG = Labour productivity growth

NA-CD = Effect of capital deepening, including tangible and 'old' intangibles

NI-CD = Effect of capital deepening of new intangibles

TPF = Total factor productivity growth

AV = Average, unweighted

Source: Provisional estimates prepared by the INNODRIVE team.

Measuring the growth of living standards

'Standard of living' is a generic concept frequently used in the public debate without any precise indication of its statistical content. In contrast GDP per capita is regularly used in international comparative studies as an initial indication of the level of 'development' of an economy and often viewed as the best proxy of living standards as well. But the use of per capita GDP as a proxy for living standards has several drawbacks. As already shown by Maddison in the 2007 study quoted above, the share of overall output being ploughed back into the capital stock and hence the share of output being made available for consumption may vary significantly over a longer time span.

When aiming at measuring the change in living standards over longer periods, it is therefore desirable to focus on the part of output available for private consumption. For the purpose of the present analysis, the development of private consumption in real terms has therefore been considered the most appropriate indicator. It should be stressed that using private consumption in real terms as the indicator for living standards involves disregarding a number of 'immaterial' determinants of the 'quality of life'. In particular, the inequality of the distribution of consumption and other aspects of the quality of life, such as the quality of the environment, are also disregarded, at least in the present phase of the study.

As shown in Table 7. Growth of private consumption per capita (% in 2000 prices)

	1960–2010	**1960–70**	**1970–80**	**1980–90**	**1990–2000**	**2000–10**

Belgium	2.4	4.0	3.8	1.9	1.7	0.4
Denmark	1.8	3.2	1.5	1.4	1.5	1.2
West Germany	2.2	4.0	3.3	1.8	1.6	0.4
Ireland	2.9	4.2	2.6	1.6	4.8	1.0
Greece	2.6	3.0	4.3	1.7	1.5	2.4
Spain	2.8	6.5	2.8	2.1	2.3	0.4
France	2.7	6.1	3.1	1.8	1.3	1.3
Italy	2.4	4.3	3.4	2.6	1.6	-0.1
Luxembourg	2.9	5.7	3.9	2.4	2.0	0.6
Netherlands	1.8	3.7	2.5	0.7	2.4	0.0
Austria	2.6	4.9	3.9	2.1	1.5	0.7
Portugal	3.1	3.5	3.8	3.9	3.4	0.8
Finland	2.9	5.5	2.9	3.1	0.9	2.0
Sweden	2.0	4.8	1.3	1.5	1.2	1.1
UK	2.4	3.0	2.1	3.4	2.6	1.0
Norway	2.3	1.7	3.2	1.4	2.8	2.2
US	2.2	2.9	2.2	2.5	2.4	1.0
Japan	2.4	3.1	3.5	3.4	1.1	0.8
Canada	3.1	7.9	2.9	1.5	1.4	1.8
Average	2.5	4.3	3.0	2.1	2.0	0.9
Average weighted	2.4	3.9	2.8	2.5	1.9	0.9
Standard deviation	0.4	1.5	0.8	0.8	0.9	0.7
Coefficient of variation	0.2	0.4	0.3	0.3	0.5	0.8

Source: AMECO database (European Commission, DG for Economic and Financial Affairs).

As was the case with the growth of total factor productivity, the growth of real per-capita consumption was drawn down exceptionally during the last decade as a result of the 2007–09 recession.

A comparison of the overall trend in total factor productivity with that of per capita consumption shows a striking convergence. As illustrated in Figure 4 for the 19 countries taken together, the gap between the two growth curves was around 1 percentage point during the 1960s. It widened to 1.5 percentage points during the 1970s but then narrowed progressively during the following three decades to only 0.4 points during the 2000–10 period.

As already illustrated in Figure 4, the difference between the growth of living standards and that of total factor productivity seems to be decreasing over time. In fact, the introduction of a proxy for each of the five periods in the regression over the data for the ten-year periods and 19 countries does yield some improvement in the statistical fit: the correlation coefficient is marginally higher and the coefficient of the time variable is also statistical significant.

The more detailed examination of the correlation between the ten-year growth rates for total factor productivity and private consumption per capita in Figure 5 illustrates the existence of a long-term ‘iron law’ between the two indicators, with a high coefficient of correlation (R^2 = 0.72) and a high statistical significance (T=15.4).

the standard of living, measured as the level of private consumption per capita in 2000 prices, in the 19 countries included here rose on average for the full 1960–2010 period by 2.4% per year. During this period the rate of growth slowed down significantly, however, from 3.9% per year in the 1960s to 2.8% in the 1970s, 2.5% in the 1980s and 1.9% in the 1990s to a low of 0.9% in the decade from 2000 to 2010.

Table 7. Growth of private consumption per capita (% in 2000 prices)

	1960–2010	**1960–70**	**1970–80**	**1980–90**	**1990–2000**	**2000–10**
Belgium	2.4	4.0	3.8	1.9	1.7	0.4
Denmark	1.8	3.2	1.5	1.4	1.5	1.2
West Germany	2.2	4.0	3.3	1.8	1.6	0.4
Ireland	2.9	4.2	2.6	1.6	4.8	1.0
Greece	2.6	3.0	4.3	1.7	1.5	2.4
Spain	2.8	6.5	2.8	2.1	2.3	0.4
France	2.7	6.1	3.1	1.8	1.3	1.3
Italy	2.4	4.3	3.4	2.6	1.6	-0.1
Luxembourg	2.9	5.7	3.9	2.4	2.0	0.6
Netherlands	1.8	3.7	2.5	0.7	2.4	0.0
Austria	2.6	4.9	3.9	2.1	1.5	0.7
Portugal	3.1	3.5	3.8	3.9	3.4	0.8
Finland	2.9	5.5	2.9	3.1	0.9	2.0
Sweden	2.0	4.8	1.3	1.5	1.2	1.1
UK	2.4	3.0	2.1	3.4	2.6	1.0
Norway	2.3	1.7	3.2	1.4	2.8	2.2
US	2.2	2.9	2.2	2.5	2.4	1.0
Japan	2.4	3.1	3.5	3.4	1.1	0.8
Canada	3.1	7.9	2.9	1.5	1.4	1.8
Average	2.5	4.3	3.0	2.1	2.0	0.9
Average weighted	2.4	3.9	2.8	2.5	1.9	0.9
Standard deviation	0.4	1.5	0.8	0.8	0.9	0.7
Coefficient of variation	0.2	0.4	0.3	0.3	0.5	0.8

Source: AMECO database (European Commission, DG for Economic and Financial Affairs).

As was the case with the growth of total factor productivity, the growth of real per-capita consumption was drawn down exceptionally during the last decade as a result of the 2007–09 recession.

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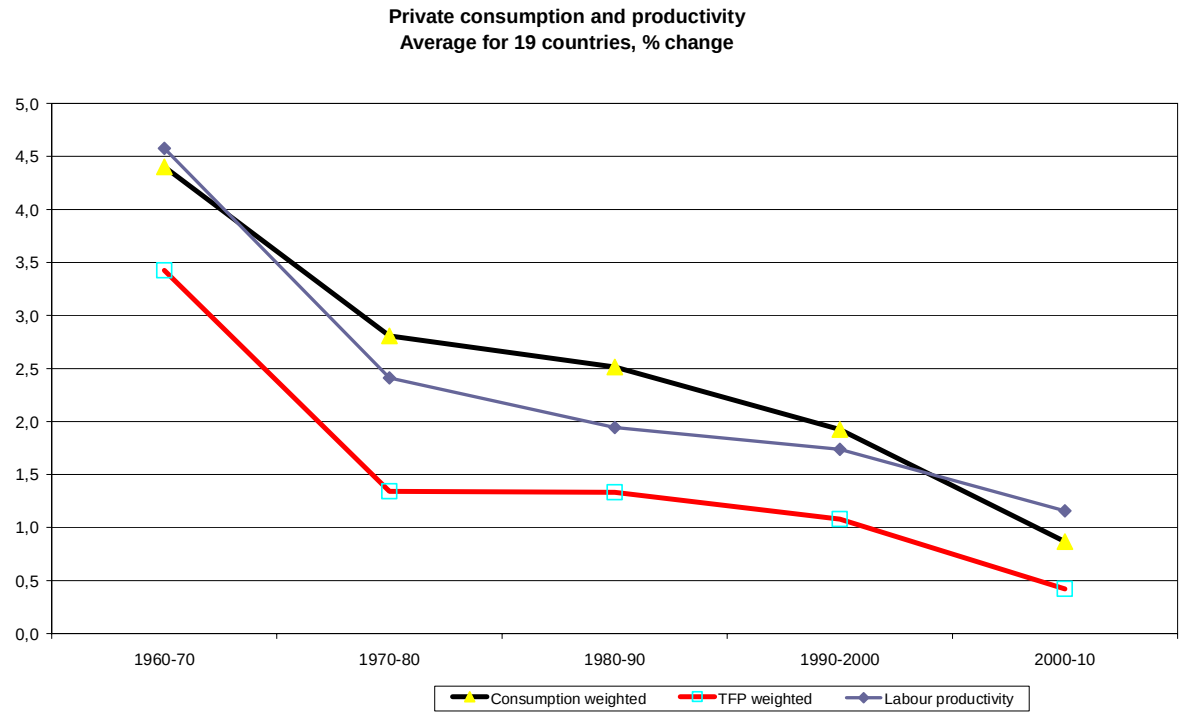
As already illustrated in Figure 4, the difference between the growth of living standards and that of total factor productivity seems to be decreasing over time. In fact, the introduction of a proxy for each of the five periods in the regression over the data for the ten-year periods and 19 countries does yield some improvement in the statistical fit: the correlation coefficient is marginally higher and the coefficient of the time variable is also statistical significant.

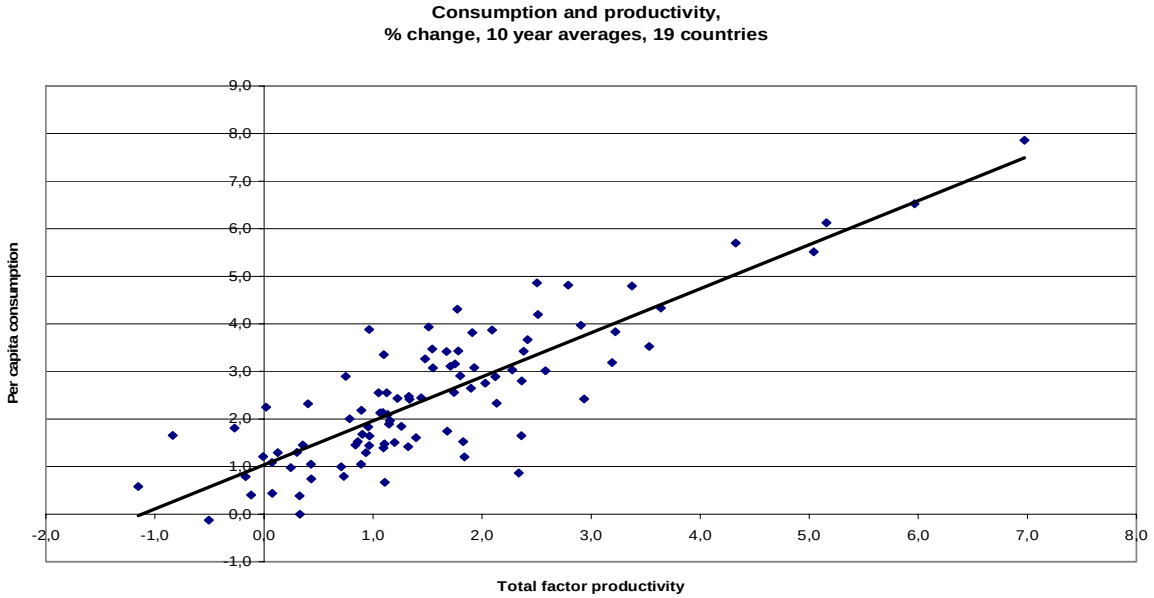
The more detailed examination of the correlation between the ten-year growth rates for total factor productivity and private consumption per capita in Figure 5 illustrates the existence of a long-term 'iron law' between the two indicators, with a high coefficient of correlation (R^2 = 0.72) and a high statistical significance (T=15.4).

Figure 4. The parallel evolution of consumption and productivity



Source: AMECO database (European Commission, DG for Economic and Financial Affairs).

Figure 5. Factor productivity and per capita consumption



Source: AMECO database (European Commission, DG for Economic and Financial Affairs).

The long-term difference between the two growth rates, about 1 percentage point, should not be taken as an indication that the 'economic system' allows an increase in living standards over and above the increase in the basic productivity variables. Indeed, the measurement of both variables poses large problems and needs to be examined in detail.

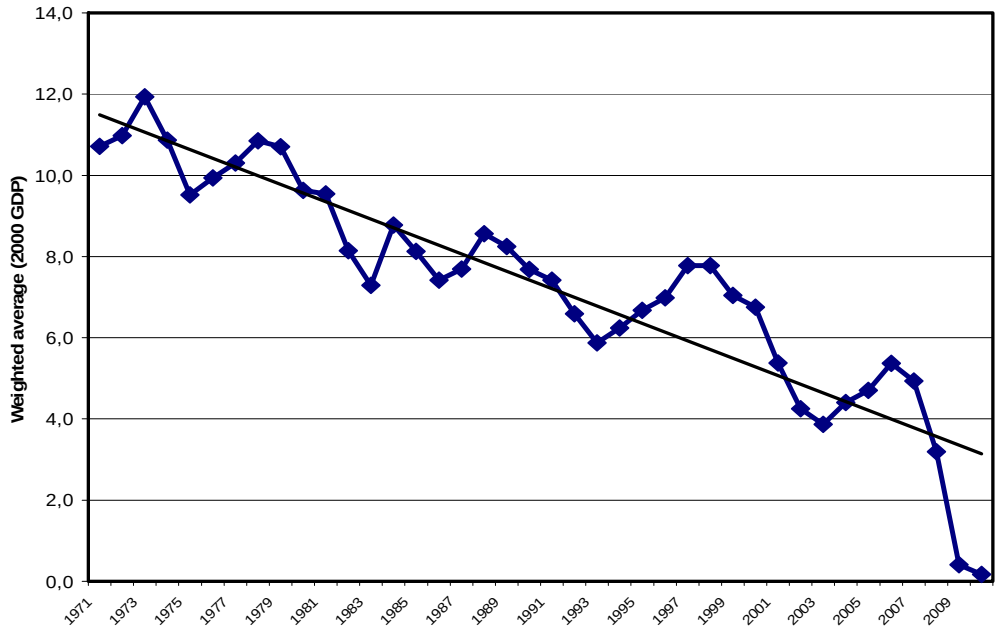
There are several potential causes of differences between the growth rates in the two datasets:

- The growth of private consumption is influenced by changes in the rate of household saving: a decline in the saving ratio may result in consumption rising faster than productivity and vice versa.
- The deflation of private consumption will not necessarily coincide with the approach to deflation of output. The difference between the two series may therefore constitute a camouflage of measurement problems.
- In an open economy, changes in the current external account will add to or subtract from the purely domestic consumption possibilities: an increase in net exports in real terms should, in principle, reduce the scope for internal spending, while in contrast a decline in real net exports should be expected to increase the scope for domestic spending over and above the change in productivity. To some extent this indicator can also be assumed to be a proxy for the overall effects of changes in the saving ratio, in so far as the latter will mirror changes in the external balance.
- The growth of private consumption per capita of population is influenced by the changes in the demographic dependency ratio: an increase in the demographic dependency ratio, that is, the number of persons in the age class 0-14 and 65+ in proportion to the working age population of 15-64 years old, should be expected to lead to 'confiscation' of part of the productivity increase of the working population. Conversely, a decline in the dependency ratio, for example due to a fall in fertility, should be expected to allow the working population to 'retain' more of the increase in productivity compared with a situation with unchanged proportions between the inactive and the active population.

Among these four potential factors, data on the evolution of the saving ratio of households are unfortunately not available in the European Commission's database for the full period considered here. Nevertheless, an admittedly crude interpretation of available incomplete data suggests that, on average for the 19 OECD countries included in the present paper, private sector net saving has declined at an unprecedented rate from 1970 to 2010, with an especially steep drop in 2009 and 2010. To the extent that series are incomplete, the level observed for the first year available has been assumed, as an initial approximation, to have prevailed during previous years. The decline in the average is strongly influenced, indeed determined by the pronounced fall in private savings in the US, accounting (2000 GDP weights) for some 40% of the total for this group of countries (Figure 6).

Furthermore, confirming the rough estimate of the ratio of private savings to GDP, various studies of the ratio of private and public debt to GDP undertaken in particular to examine the nature of the 2007–08 financial crisis, have shown a rise of total household debt in the US from some 20% of GDP in 1960 to around 100% in 2010. And a study by the consultance McKinsey[16] shows household debt in the range of 75-120% of GDP in such countries as Japan, Britain, South Korea, Switzerland and Spain and appreciable levels in several other countries as well. It is thus highly likely that the strong increase in household debt during the period from 1960 to 2007 has allowed private consumption to increase substantially faster than the rate warranted by the rise in multi-factor productivity.

Figure 6. Private saving (% of GDP), weighted average of 18 OECD countries, 1970–2010



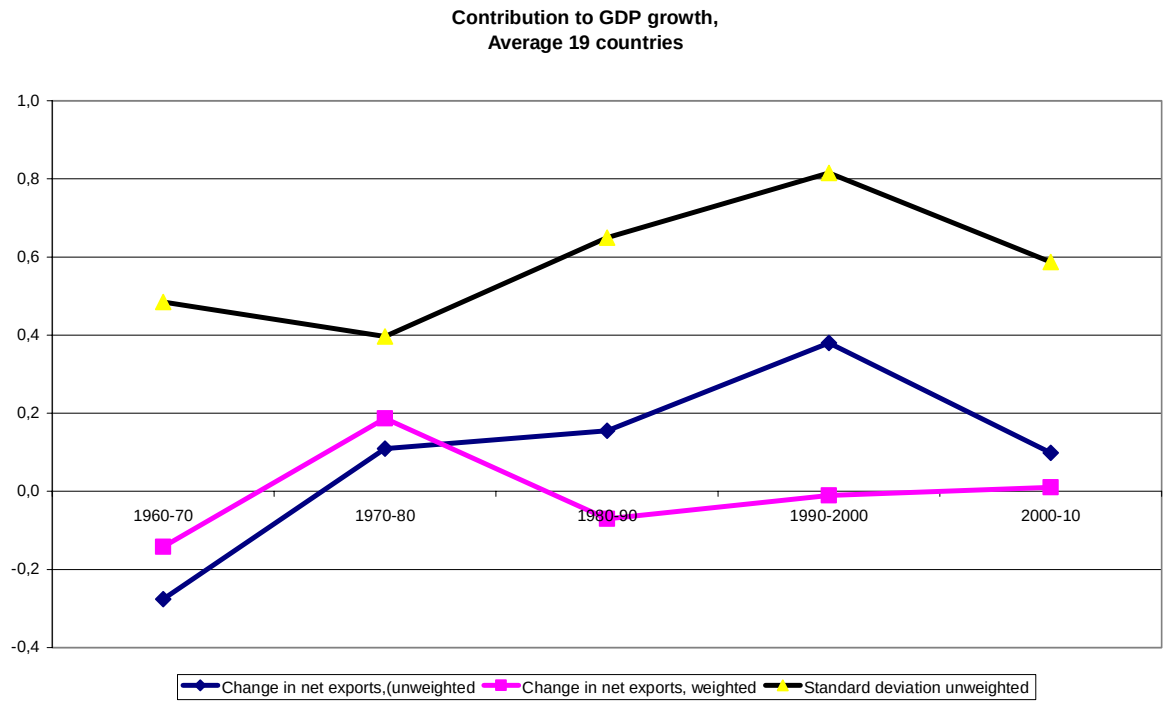
Source: Eurostat, with several adjustments and assumptions (see text).

[16] Reported in T*he Economist* 26 June 2010.

In terms of macroeconomic equilibrium, other things being equal the decline in net domestic saving should have, as a counterpart, a corresponding shift in the external balance in real terms with a fall in net exports. This hypothesis is also confirmed by the available data.

On average for the decade 1960–70, changes in the overall real external balance for the 19 countries covered, weighted with the share in population, were slightly negative but in the following decade they shifted in the opposite direction. During the subsequent three decades there was little overall change in the weighted average. It is nonetheless striking that within this group some countries experienced pronounced differences from one decade to another. As seen in Figure 7 the unweighted average shows a strong increase from the 1970s to the 1990s with a resulting marked rise in the standard deviation of the observations for the individual countries.

Figure 7. Contribution to GDP growth of net exports (percentage points)



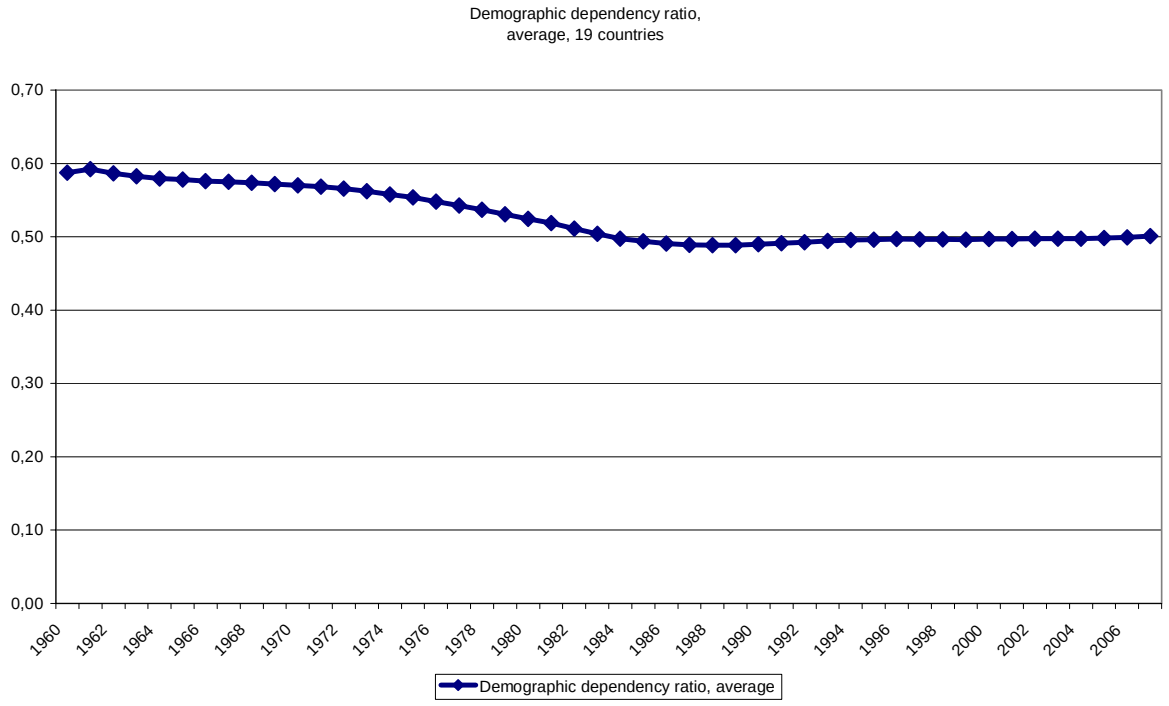
Source: AMECO database (European Commission, DG for Economic and Financial Affairs).

As regards the demographic dependency, an increase should be expected to limit the availability of resources overall for an increase in the standard of living. As shown in Figure 8, on average for these 19 countries the demographic dependency ratio, owing essentially to the decline in fertility in the 1970s and early 1980s, fell from around 0.6 in 1960 to some 0.5 in the middle of the 1980s and then stayed roughly at this level until 2007, the last year for which data are available in the AMECO database. The demographic 'dividend' can thus be expected to have allowed some additional boosting of private consumption during the first couple of decades but to have dried up from around 1990, when the effects of the continued ageing of the population compensated the echo effects of the decline in fertility on attendance in education.

Inserting the three main determinants of the change in private consumption – the growth of total factor productivity, changes in the demographic dependency ratio and the real net external balance of goods and services – the result is an excellent fit, with an R^2 of 0.8 and a satisfactory statistical significance of the four coefficients. All in all, the examination provides some evidence that an increase of 1 percentage point in the demographic dependency ratio can be expected to reduce the rate of growth of private consumption by some 0.05 percentage points while an improvement in the external balance, amounting to say, 1 percentage point of GDP, would have as its counterpart a reduction of 0.6 of a percentage point in the growth rate of private consumption in volume terms (Table 8.).

Instead of the external volume balance, here used as a proxy, an attempt to introduce the private saving ratio in the regression results in a considerably less significant fit, due in particular to a strong variability of the latter for individual countries and years, which is not reflected in the evolution of private consumption from year to year. It therefore seems more appropriate to use the external volume balance as the best indicator for the state of the domestic balance between available resources and consumption.

Figure 8. Demographic dependency ratio



Source: AMECO database (European Commission, DG for Economic and Financial Affairs).

As indicated above, full and direct data on the household saving ratio are not available in the Eurostat database. Still, as is clearly illustrated in Figure 4 the gap between the growth rate of private consumption per capita and total factor productivity has clearly narrowed through time, no doubt because the scope for financing consumption through a rise in net debt gradually reduced during the 1970–2000 period.

Introducing time as a proxy for this likely reduction in the scope for financing the rise in consumption through debt unsurprisingly results in a marked loss of significance of the external balance and also in a lower coefficient for factor productivity and with a higher intercept.

Table 8. Determinants of the change in real private consumption

	Coefficient	T-stat
Excluding a time variable		
Intercept	1.06	9.56
Total factor productivity	0.90	17.34
Demographic dependency ratio	-4.83	-3.34
Net external balance	-0.58	-5.22
R square	0.80	–
Including a time variable		
Intercept	1.95	6.63
Total factor productivity	0.76	11.12
Demographic dependency ratio	-4.52	-3.08
X-M	-0.46	-4.10
Time	-0.22	-3.33
R square	0.82	–

Source: Own calculations.

Do we measure inflation and productivity correctly?

Whereas the initial hypothesis was that multi-factor productivity would be the basic determinant of living standards, the presentation in Figure 4 and the regression in Table 8. shows an important systematic difference, expressed as an intercept value of around 1%, suggesting, in simple terms, that living standards have been increasing about 1 percentage point faster than multi-factor productivity. A question arising is therefore whether this systematic difference is 'real' or whether the difference could actually be due to differences or even errors in the measurement of the two variables.

A major general problem with the current, universally applied measurement of price increases is that it is usually based on the assumption of *unchanged behaviour and an unchanged basket of goods and services.*[17] Consumer and producer prices are most often calculated as the Laspeyres indexes, compiled by weighting price changes in the multitude of goods and services entering into the index with their share in the 'basket' in a base year, most often a year in which the household budgets have been analysed through household surveys or where comprehensive data on production are available.

A Laspeyres index thus takes no account whatsoever of the phenomenon that is and should be part and parcel of consumer and producer behaviour over the coming decades: the changes in behaviour and the scope for *substitution* of certain goods and services by new and innovative goods and services. There is broad scientific support for the view that the scope for such technological innovations is very large, if the incentives and price signals are appropriate. The problem with base-year weighted indexes is, indeed, one of the classical features of statistical

[17] The following is partly an extract from the CEPS Working Paper by Mortensen and Frale (2008), op. cit., providing more details and examples of the effect of changes in weighting schemes.

methodology and early on the statisticians designed essentially two alternative methods of measuring price increases: an index with *end-year* weights, named after Hermann Paasche, and an average of the two, the Fisher index, named after Irving Fisher, who proposed this as the most appropriate formula. The difficulty with the Paasche index is that it must be calculated for a recent period for which data on household budgets and output of production will not necessarily be available and for which the design of the weighting scheme therefore remains uncertain. What is conceptually certain, however, is that because of the scope for substitution the Laspeyres index always delivers a higher inflation estimate than the Paasche index and the higher the difference the larger the degree to which agents escape the effect of the rise in prices of certain goods and services through switching to other categories.

Statistical offices have recently attempted to restrain this substitution bias by using a different procedure of aggregation for the basic price indexes, the so-called 'chain-link' approach. The new, chained consumer price indexes are based on a weighting scheme that compares each month with the previous month, weighting those changes by the importance of each good in both periods, and chaining back to the base period. This methodology does not solve the problem of substitution bias completely and has its cost: the new series discounts an increased complexity of computation and interpretation and lacks the additive property. As a result, for example the series of GDP in constant prices is no longer the sum of its expenditure components (consumption, investments and external balance).

A compromise procedure, avoiding the drawbacks of a chain weighting scheme, could involve a weighted constant-elasticity-of-substitution (CES) aggregator, as suggested in a US Federal Reserve working paper,[18] assuming that utility takes a Cobb-Douglas form as a special case. According to this working paper, such a procedure is already employed by the US consumer price index to aggregate *individual prices* (that is, prices *within* item-area strata) with a geometric means formula used for the majority of cases and a Laspeyres formula reserved for strata where substitution is deemed unlikely a priori. With fuel substitution this would imply an assumption that consumers and producers keep the share in overall spending of a specific category of goods and services more or less constant and that they consequently increase their use of other goods and services so as to keep their overall 'utility' at the same level.

Nevertheless, as stressed notably by Leonard Nakamura,[19] a simple way to measure the gain from new goods could be to measure the *decline* in the price of an existing and now obsolete good of the same type as the new good. If the new good's introductory price relative to the existing good reflects the difference in quality between the new good and the existing one, then the decline in the price of the old one would tend to reflect the gain in consumer utility. This could then be taken into consideration in measuring 'inflation' with account taken of this improvement in utility.

But a further challenge is posed by the fact that new goods and services may have additional externalities owing to consumer learning and associated changes in habits. For example, the introduction of innovative pharmaceutical or cosmetic products or ICT equipment may induce new 'knowledge' and new attitudes, and thus provide additional utility as an externality, not taken into account in the conventional price index.

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[18] D.E. Lebow and J.B. Rudd, *Inflation Measurement*, Staff Working Paper 2006-43, Federal Reserve Board, Washington, D.C., 2006.

[19] L. Nakamura, *Intangible assets and national income accounts: Measuring a scientific revolution*, Working Paper No. 09-11, Research Department, Federal Reserve Bank of Philadelphia, 8 May 2009.

In the view of many observers, the failure of inflation indicators to take account of such quality changes and externalities may over a long time have resulted in a serious over-estimation of inflation and the gap between the measured, apparent and the true rate of inflation may have increased over recent decades through an accelerated speed of innovation in many of the goods and services produced and consumed.

Furthermore, as demonstrated in a number of recent studies, the difficulties involved in the splitting of a nominal change in consumption or output have been exacerbated by the increasing role of intangible goods and services in the economy. In the case of many services and practically all intangibles, the definition of a unit of volume and a price is much more problematic than for a tangible good. Faced with the difficulties in defining, for example, the output of a medical doctor, statistics have in general measured output in terms of the 'input' of time, with the appalling result that the 'quality' of a medical consultation or a surgery lasting one hour in 2010 will not have been modified compared with the situation, say, 50 years earlier. In reality, however, there has evidently been a huge improvement in the quality of medical services, in terms of both the quality of medical equipment and the human capital of the medical personnel.

Given the very large rise in the role of services and intangibles in the economy, it is therefore likely that the upward bias in the estimates of price increases has been rising through time and hence the slowdown in the growth of living standards has been much less pronounced than suggested in Table 7. Growth of private consumption per capita (% in 2000 prices)

	1960–2010	**1960–70**	**1970–80**	**1980–90**	**1990–2000**	**2000–10**
Belgium	2.4	4.0	3.8	1.9	1.7	0.4
Denmark	1.8	3.2	1.5	1.4	1.5	1.2
West Germany	2.2	4.0	3.3	1.8	1.6	0.4
Ireland	2.9	4.2	2.6	1.6	4.8	1.0
Greece	2.6	3.0	4.3	1.7	1.5	2.4
Spain	2.8	6.5	2.8	2.1	2.3	0.4
France	2.7	6.1	3.1	1.8	1.3	1.3
Italy	2.4	4.3	3.4	2.6	1.6	-0.1
Luxembourg	2.9	5.7	3.9	2.4	2.0	0.6
Netherlands	1.8	3.7	2.5	0.7	2.4	0.0
Austria	2.6	4.9	3.9	2.1	1.5	0.7
Portugal	3.1	3.5	3.8	3.9	3.4	0.8
Finland	2.9	5.5	2.9	3.1	0.9	2.0
Sweden	2.0	4.8	1.3	1.5	1.2	1.1
UK	2.4	3.0	2.1	3.4	2.6	1.0
Norway	2.3	1.7	3.2	1.4	2.8	2.2
US	2.2	2.9	2.2	2.5	2.4	1.0
Japan	2.4	3.1	3.5	3.4	1.1	0.8
Canada	3.1	7.9	2.9	1.5	1.4	1.8
Average	2.5	4.3	3.0	2.1	2.0	0.9
Average weighted	2.4	3.9	2.8	2.5	1.9	0.9
Standard deviation	0.4	1.5	0.8	0.8	0.9	0.7

Coefficient of variation	0.2	0.4	0.3	0.3	0.5	0.8

Source: AMECO database (European Commission, DG for Economic and Financial Affairs).

As was the case with the growth of total factor productivity, the growth of real per-capita consumption was drawn down exceptionally during the last decade as a result of the 2007–09 recession.

A comparison of the overall trend in total factor productivity with that of per capita consumption shows a striking convergence. As illustrated in Figure 4 for the 19 countries taken together, the gap between the two growth curves was around 1 percentage point during the 1960s. It widened to 1.5 percentage points during the 1970s but then narrowed progressively during the following three decades to only 0.4 points during the 2000–10 period.

As already illustrated in Figure 4, the difference between the growth of living standards and that of total factor productivity seems to be decreasing over time. In fact, the introduction of a proxy for each of the five periods in the regression over the data for the ten-year periods and 19 countries does yield some improvement in the statistical fit: the correlation coefficient is marginally higher and the coefficient of the time variable is also statistical significant.

The more detailed examination of the correlation between the ten-year growth rates for total factor productivity and private consumption per capita in Figure 5 illustrates the existence of a long-term 'iron law' between the two indicators, with a high coefficient of correlation (R^2 = 0.72) and a high statistical significance (T=15.4).

and Figure 4.

The upward bias in inflation measurement and the resulting downward bias in the measurement of private consumption in real terms is likely to have been in operation also with respect to the measurement of output and productivity in the production account. Yet since measurement methods and definition of the baskets of, respectively, consumer goods and services and the output of the production process are not necessarily totally consistent, the possibility of different amplitudes of this bias is not to be excluded on the basis of *ex ante* arguments.

A hypothesis, but one that is extremely difficult to verify, would be that the lowering of the gap between the rise in real consumption per capita and the rise in total factor productivity shown in Figure 4 could be due to an approximation of measurement errors in consumption and output and not to any underlying changes in the 'iron law' of productivity. Pending much deeper exploration of this methodological minefield, the operational assumption is therefore that over and above possible measurement errors, living standards will in the future be determined essentially by the evolution of productivity as adjusted for the evolution of the dependency ratio and the external volume balance.

Future growth of living standards: An assessment

Total factor productivity

Considering now the prospects for changes in total factor productivity in the 19 countries over the coming decades, a first step will unavoidably be to assess the long-term effects on productivity growth of the recession of the years 2008–09.

As stressed in a report from the European Commission published in 2009 and thus at a time when the crisis was still unfolding, the rate of growth of potential output and productivity

cannot necessarily be assumed to return to the trajectory followed during the years preceding the crisis.[20]

Indeed, according to the report's Executive Summary, a review of the economic literature identifies several channels through which the crisis could impact on potential output levels and growth rates:

- A crisis could reduce potential output in the short and medium terms through its adverse impact on investment. The ensuing slower capital accumulation could be combined with acceleration in the obsolescence of some capital vintages stemming from economic restructuring.
- A slow process of industrial restructuring, caused for example by credit constraints, an impaired system of capital allocation or by entrenched structural rigidities, could also hurt the level and growth rate of total factor productivity in the medium to long term by locking resources in (relatively) unproductive activities.
- Growth in total factor productivity in the medium to long run could also be curtailed by depressed investments in private R&D, which are markedly pro-cyclical. Drivers of total factor productivity, such as physical investment, R&D and innovation, may also suffer from a prolonged recession and from the shifts in attitudes towards risk, resulting in a tightening of credit conditions and an increase in the cost of capital.
- A short recession would not affect the pace of growth of the labour force, leaving potential growth unharmed in the longer run. But a long and deep recession may cut the potential labour force by discouraging some workers from seeking a job and by reducing migration flows. Moreover, political pressures to implement policies that would curtail labour market participation (e.g. early retirement, curbs on migration flows) may increase. Equally, if short-term, crisis-related measures (e.g. a temporary increase in unemployment benefits) are not reversed in the recovery phase then this would further reduce employment.
- Finally, in the case of a prolonged recession, long unemployment spells may cause a permanent destruction in human capital, leading to an irreversible rise in the non-accelerating inflation rate of unemployment (NAIRU) – due to so-called 'hysteresis effects' – and further losses in the potential output level. By contrast, the NAIRU is not likely to affect the long-term pace of potential growth, since this would implausibly require that it permanently increases over time.

On balance, according to the report, the risks are on the downside and the prospect of the crisis having a negative impact on long-run potential growth rates cannot be excluded, particularly if financial conditions remain more restrictive in the long run, thereby negatively affecting R&D investments and the growth rates of total factor productivity.

Over the coming decades chances are that tangible and intangible capital deepening will eat up most or all of the increase in labour productivity, or rather that the apparent increase in labour productivity will be obtained essentially through an increase in the use of tangible and intangible capital in the economy.

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[20] G.-J. Koopman and I.P. Székely (eds), *Impact of the current economic and financial crisis on potential output*, European Economy, Occasional Paper No. 49, Directorate-General for Economic and Financial Affairs, European Commission, Brussels, June 2009.

In addition to the possible negative effects of the crisis, at least over the decade from 2010 to 2020, changes in the underlying growth of total labour and factor productivity could occur as a result of changes in the capital intensity of the economy if more of output needs to be ploughed back into the economy in the form of tangible or intangible investment. As shown above in Table 1, reproducing the estimates made by Maddison (2007), during the period from 1870 to 1913 the US experienced a pronounced rise in the capital/output ratio, largely through the huge investments in manufacturing and in infrastructure. The counterpart of this was, as already indicated, the slow growth of factor productivity and thus of the living standards of the population.

Several elements would seem to point to a need for a considerable enhancement of investment and tangible and intangible capital stock over the coming decades:

- A reduction in the carbon intensity of the world economy will require a significant expansion of renewable energy sources, such a solar energy. Solar energy comes cheap once the solar panels and the system of distribution have been put in place. At the same time, the investment needed to produce a gigawatt of electricity using solar panels or nuclear power is markedly higher than the investment required to produce electricity with coal, oil or gas.
- The reduction of the energy intensity of the economy will require fundamental changes in the use of energy in all branches and in all categories of consumption. This will be achieved without investment in knowledge, R&D or fixed capital.
- The adaptation to the unavoidable climate change, for example the construction of dykes or finding new ways of economising water, requires capital formation up front with the benefit accruing from later improvements in the quality of life.
- Coping with the environmental challenges, reducing pollution and recycling waste will also necessitate substantial investment in both intangible and tangible capital, through further R&D and improvements in technology, investment in new equipment for recycling and finding other ways of cleaning up the environment.

On the brave assumption that the use of fossil fuel per unit of GDP were reduced by, say, 10% per decade over the next 40 years, the overall result would be a certain reduction in the relative level of input of energy into the production process. This reduction, other things being equal, would have as the counterpart a higher relative level of value added and a higher level of depreciation. The process could look much like the period from 1870 to 1913 in the table by Maddison reproduced above (Table 1). During this period, as shown, the rate of growth of total labour productivity (1.93) in the US was quite high but the largest part of this apparent productivity increase was obtained through significant capital deepening and the resulting growth of total factor productivity was only 0.36% per annum.

Tentatively a projection of total factor productivity growth over the coming decades has been made on the basis of the following assumptions:

- In the leading economy, the US, multi-factor productivity could be assumed to grow in line with the average over the period 1973 to 2003 as estimated by Corrado, Hulten and Sichel (2006) (Table 5), including the effect of intangibles on capital deepening and the ongoing changes in labour composition. Taking a simple average of the two sub-periods, multi-factor productivity in the US could hence be projected to grow by at most 0.75% per annum and slower growth is not to be excluded a priori.
- Multi-factor productivity of the other countries in the sample could be expected to converge towards the US level, in the sense that the annual rate of growth of countries

with a relatively low level of productivity could be expected to continue along the trend observed during the period from 1970 to 2000 (thus leaving out the special effects of the 2008–09 recession) but with the gap *vis-à-vis* the US being reduced progressively as the state-of-the-art technology is gradually adopted around the world. This would, in any case, imply a much higher rate of tangible and intangible capital deepening in the countries with low per capita GDP in proportion to the leading economies.

All in all, the growth of total factor productivity in these countries on average can be expected to be significantly lower than the underlying trend of 1% per annum seen during the 1980s and 1990s, and disregarding the slowdown in the recent decade, attributable in large part to the crisis (Further details of the projection are provided in the bow, below).

Box 1. Projecting multi-factor productivity

The tentative (illustrative) projection of the growth of multi-factor productivity over the period 2010 to 2030 has been done on the basis of a few simple assumptions:

1. The link between the growth of total factor productivity and the level of per capita GDP *vis-à-vis* the US has been assumed to prevail: Trendline: 2.59-1.57*PerCapitaGDP as indicated in Figure 3.
2. For the period 2010 to 2030, however, this relation takes its starting position in year 2010 and thus takes account of the significant lowering of the disparities with respect to GDP per capita since 1960.
3. The intercept has been adjusted to allow for both the increasing role of intangibles not included in the conventional measure of total factor productivity and the prospective increase in tangible and intangible capital deepening during the 2010–30 period. The intercept has therefore been reduced across the board by half a percentage point. This adjustment hence affects all countries in the sample. Notably, Luxembourg and Norway, which for very different reasons have a level of per capita GDP in 2010 that is well above that of the US, have not been included in this projection.

It should be stressed, at this stage, that the tentative projection of a continued, albeit slow, increase in multi-factor productivity, may well prove over-optimistic. In fact, as argued forcefully in a report by Professor Tim Jackson, published in March 2009 by the UK Sustainable Development Commission[21] transition to a sustainable economy will need enhanced investment in public infrastructures, sustainable technologies and ecological maintenance and protection to a degree not hitherto seen at all levels of economic development. In addition, as argued by Jackson, new macro-economics for sustainability must "abandon the presumption of growth in material consumption as the basis for economic stability. It will have to be ecologically and socially literate, ending the folly of separating the economy from society and environment" (Jackson, page 10).

The total dependency ratio

Although the very long-term demographic prospects remain dependent on the assumptions concerning fertility and life expectancy, the demographic forecasts up to year 2050 for the main regions in the world can be elaborated with a relatively narrow margin of uncertainty. The overall dependency ratio for the 19 countries covered can therefore be assumed to rise from the current level of some 50%, as shown in Figure 8, to around 70% in year 2050, that

[21] Jackson, Tim : *Prosperity without growth ?: The transition to a sustainable economy*, Sustainable Development Commission, March 2009. http://www.sd-commission.org.uk/

is, by some 5 percentage points per decade. Expressed in the dimension of shares, used in Table 8, the dependency ratio can thus be projected to rise, on average for these countries, by 0.05 points per year.

If it could be assumed that past relations between the dependency ratio and the change in private consumption per capita of the population holds, the overall rate of growth of the latter, solely as a result of the rise in the dependency ratio, would be reduced by 0.25 percentage points per year. Considering that the rate of growth of the standard of living has declined to around 1% in the recent decade, the prospective rise in the dependency ratio can be expected to exert a strong dampening effect, reducing the growth rate from 1 to 0.75% per annum. On an annual basis, this gap does not appear large but accumulated over a period of 20 to 40 years, the final outcome is a significantly lower level of standard of living per capita in the end-year.

The effect of a reduction of the debt overhang

Although the need for a lowering of public debt in most of the countries covered in the present paper was in focus in the early months of 2010, the need for a lowering of the private debt overhang was recognised by observers but much less discussed in the media. Nevertheless, the steep decline in private saving in proportion to GDP, shown in Figure 6, obviously cannot be expected to continue and on the contrary should be assumed to reverse during the coming decade. There is also a recognised need for a pronounced consolidation of public finance, and a corresponding improvement in the net saving of general government in a number of highly important countries. On the other hand, the need for a parallel lowering of public and private debt in proportion to GDP is seen by observers and analysts as a powerful source of deflationary tendencies that in principle could only be countered by an expansion of net exports to satisfy a rising consumption in the rest of the world.

Regardless of whether the negative effect on output growth of the likely increase in household saving is absorbed to some extent by an increase in net exports it will not, of course, directly increase the scope for per capita consumption, but it could boost overall output and employment and, hopefully, also productivity.

Prospects for the net external balance

As shown in Figure 7, the weighted series of net exports for the 19 countries covered contributed only marginally to the overall growth in living standards over the 1960–2010 period. Clearly, individual countries may for shorter periods experience swings in the national ratio of saving to income with, as a counterpart, swings in the external balance. For example, the US experienced an extended period of large external deficits, allowing households in this economy to 'live on borrowed money'. However, the bursting of the bubble in 2007–09 showed that this development was not sustainable and is now assumed to be reversed, with, as the counterpart, an increase in domestic saving and a corresponding rise in net exports.

Projections of the contribution to GDP growth of improvements in the external balance are, beyond doubt, the most uncertain to undertake and would indeed require a more thorough examination of competitiveness and resources than possible in this context. The present tentative projection has been made on the simple-minded assumption that the accumulated change during the 1980–2010 period would be followed by a change in the opposite direction. The implication of this assumption is that countries such as the US – which during the years 1980–2010 has experienced a negative GDP contribution from the external side (implying that net exports have fallen in volume terms) – would need over the period 2010–30 an

equivalent improvement (an increase in net exports), which, due to the negative coefficient of this variable, would reduce the scope for the rise in domestic living standards.

Thus, the likely increase in household saving, as the counterpart of a lowering of the debt overhang, can be expected to result in some reduction in the domestic consumption possibilities and more strongly so for countries in need of a significant improvement in the balance of payments.

Prospects for growth of living standards

On the assumption that past correlations between the growth of total factor productivity and that of private consumption, summarised in Table 8, would also hold for the coming decades, the combined effects of the prospective increase in the dependency ratio, reduction of the debt overhang and only slow growth of total factor productivity would on average for the 19 countries provide for much slower growth of real private consumption than in the preceding decades.

On average, population-weighted, private consumption per capita could, on these tentative and illustrate assumptions, be projected to increase by only 0.6% per annum over the 2010–30 period. Given the reduction in disparities already achieved during the past 50 years, the growth of living standards would seem to be contained within a relatively narrow margin.

The general trend for these countries would nevertheless be compatible with disparities within the group, depending on the starting position with respect to both the level of productivity and the demographic developments. In countries with a relatively high level of fertility, such as the US, France, Ireland and the Nordic countries, because of a continued rise in the population of working age the scope for a further rise in living standards will suffer less than in countries such as Germany, Italy and Spain. In the latter countries the demographic shock will combine with a slow rise in productivity to severely reduce the scope for a further rise in living standards.

Yet, the prospective growth of per capita living standards may also depend importantly on the rate of employment, not taken explicitly into account above. In general, per capita consumption is projected to rise by some 0.6% per year over the period 2010 to 2030 or almost 2 percentage points less than during the period from 1960 to 2010 (Table 9). As explained in Box 1 above, the projections in this table are made using the coefficients of the regression presented in Table 8, albeit with a constant (intercept) that is smaller than the level in that table, more in line with the gap seen during the 2000–10 period (Figure 4). Disparities within the group will be determined by the initial position with respect to the level of productivity but also, importantly, by the evolution of the demographic dependency ratio, as resulting from past and future trends in both fertility and life expectancy. The latter is projected by the UN[22] to increase on average for the 19 countries included here by 0.13 points (or by 13 percentage points) with, however, the changes for individual countries ranging from only 4 percentage points in Ireland to 20 percentage points in Finland.

Countries with a low initial level of productivity, such as Greece and Portugal, will benefit from a catching-up process and hence be able to devote more resources to consumption than countries like Denmark, Sweden and Norway, which are already close to the US as regards the level of productivity.

[22] United Nations, *World Population Prospects, 2008 Revision :* http://esa.un.org/unpd/wpp2008/index.htm

Still, the prospective slowdown in the growth of living standards in a number of these countries may give rise to emerging tensions between generations as a declining number of persons in the active age classes will need to work more, better and longer for a stagnating or declining real wage so as to contribute to the maintenance of living standards of the rising number of persons in the inactive age classes.

The realistic possibility of an increase in the effective age of retirement will thus allow a dampening of the increase in the *economic* dependency ratio, which rose during several decades due to early retirement schemes and increased longevity. This change in retirement schemes may to some extent compensate the effect of the rise in the *demographic* dependency ratio albeit at the cost of an increase in the duration of working life. In a way, the reduction in the time available for leisure will be needed to maintain a 'reasonable' level of material living standards for large segments of the population.

Nevertheless, an increase in the activity ratio of persons in the age group 55 to 70 will not take place without implications for the development of productivity or additional efforts to enhance human capital (or both). Already today, in countries with a high rate of employment, such as the Nordic countries, GDP and consumption per capita are at high levels but are attained by ploughing more efforts into production and also by an exceptional effort to boost education and adult learning, that is, intangible capital, with lesser emphasis on investment in conventional fixed capital.

Table 9. Projections of productivity, dependency, net exports and living standards

	Consumption per capita % change	Multi-factor productivity % change	Demographic dependency ratio change	Net external balance contrib. change	Consumption per capita	
					% change projection	change in percentage points
	1960–2010	2010–30	2010–30	2010–30	2010–30	1960–2010 to 2010–30
EU-15	2.5	1.0	0.1	0.0	0.8	-1.7
Belgium	2.2	0.9	0.2	-0.2	0.7	-1.5
Denmark	1.9	0.9	0.1	0.0	0.8	-1.1
West Germany	2.3	0.8	0.2	-0.4	0.5	-1.8
Ireland	2.6	0.8	0.0	0.0	1.1	-1.5
Greece	3.3	1.2	0.1	0.3	0.9	-2.4
Spain	2.7	1.1	0.1	0.2	0.9	-1.8
France	2.4	1.0	0.1	0.0	0.7	-1.7
Italy	2.6	1.1	0.1	0.0	1.0	-1.6
Netherlands	2.1	0.7	0.2	-0.4	0.6	-1.5
Austria	2.4	0.8	0.2	-0.3	0.8	-1.6
Portugal	3.5	1.3	0.1	0.7	0.8	-2.7
Finland	2.7	1.0	0.2	-0.5	0.7	-2.0
Sweden	1.6	0.9	0.1	-0.6	1.0	-0.6
UK	2.2	0.9	0.1	0.2	0.8	-1.4
US	2.2	0.5	0.1	0.2	0.3	-1.9
Japan	3.3	1.0	0.2	-0.2	0.8	-2.5
Average unweighted	2.5	0.9	0.1	-0.1	0.8	-1.7
Average 2000 pop. weights	2.5	0.8	0.1	0.0	0.6	-1.9
Standard deviation	0.5	0.2	0.0	0.3	0.2	0.5

Note: Multi-factor productivity includes a projection of the effects of tangible and intangible capital deepening and improvement of the quality of the labour force.

*Source*s: Eurostat, United Nations and own calculations.

Summary and conclusions

As shown in the analysis presented above, over the long run the growth of conventionally measured labour productivity, that is, output per unit of labour input, is a biased indicator for the scope for a rise in living standards. This is essentially due to the fact that, in some periods, the increase in 'labour productivity' has been brought about by an increase in the fixed capital stock per unit of labour, that is, an increase in the so-called 'capital intensity' of the production.

For these reasons, it is crucial to adjust the productivity concept to take account of both labour input and the input of capital 'services'. The analysis shows that this adjusted productivity concept, termed total factor productivity, can be viewed as the main determinant of the rise in living standards in the long run and on average for the developed countries considered here.

An important additional issue, however, is that in the modern knowledge society more and more of capital formation is actually of an immaterial nature. The strong increase in the share of services in the economy had, as its counterpart, a decline in the share of conventional goods-producing industries. Thus, the most developed economies devote ever more resources to activities that are necessary for the satisfaction of the increase in living standards but do not directly contribute to the latter. As a consequence of the increase in the share of intangibles in the economy, fewer resources are available for an increase in living standards as conventionally measured.

At the same time, the analysis also shows that in addition to the evolution of total factor productivity, the rise in living standards owes a lot to the evolution of the proportion of the dependent population, in the age classes 0-14 and 65+, to those in the active age classes, aged 15-64 – the so-called 'total dependency ratio'. A low dependency ratio can be shown to allow a faster rise in the standard of living, while a high dependency ratio, inversely, will reduce the scope for material living standards.

A prospective analysis suggests that over the coming decades, the total dependency in the developed countries will rise significantly and hence the rise in living standards will be severely hampered because of the ageing of the population.

The 'Brussels consensus' points to the need for an accelerating productivity increase as the most important tool available for ensuring the future scope for a rise in living standards of the ageing population in a greener, less energy-intensive economy. It is, sadly enough, not easy to see from where this productivity increase would emerge:

- It is absolutely essential to stress, as already pointed out above, that a large part of future so-called 'productivity increases' will only be attained through a significant increase in the tangible and intangible capital intensity of the economy.
- A genuine increase in living standards will thus need to be achieved through an increase in total factor productivity as adjusted for the 'missing intangibles'.
- A genuine rise in total factor productivity will therefore need to be achieved through technological innovation in areas that can be assumed to produce more goods for lower prices to the consumers.

However, pending new unexpected discoveries, a large share of current research and innovation will need to address the fundamentally new tasks of investing in energy saving and pollution control. The quality of life of the entire population will no doubt in the longer run benefit significantly from such investments; but first, it will take considerable time to be felt at the level of consumers who, in the meantime, will suffer from little or no rise in living standards as conventionally measured. Second, the process of energy saving and pollution control is likely to be more strongly felt by the segments of the population that spend a high proportion of their total budget on housing, transport and adaptation to climate warming. The likely stagnation of the overall standard of living may therefore lead to increasing inequality in society.

Where as the prospects for productivity growth is the main focus of this paper, it may well be argued that the likelihood of the developed economies entering into a prolonged period of lean cows, will justify a broader reconsideration of economic and social policies. As argued

by Tim Jackson in the paper referred to above longer-term sustainability would not be helped by the pump-priming of private consumption proposed by many camps as a way to combat the crisis. It may thus well be that time is "ripe to develop a new macro-economics for sustainability that does not rely for its stability on relentless growth and expanding material throughput".

The exit from the crisis might therefore perhaps be found by defined new (or returning to old) patterns of consumption respecting the ecological limits of the planet. This in no way implies returning to the themes of the Club of Rome on "limits to growth" but rather to seek ways of promoting the well-being and quality-of-life through policies aimed at improving the work-life balance, social equity and social capital and, not least, making further progress with respect to measuring output and well being with due regard to intangibles and all immaterial aspects of society.

Thus, the provisional findings in the present working paper raise a series of questions about measurement and point to the need for a deeper exploration of the most important country cases. This would involve, in particular, an examination of the more detailed time profiles of the links between, on the one side of the equation, the evolution and measurement of living standards, and on the other side the evolution and measurement of multi-factor productivity, notably including intangibles, the evolution of household saving, the external balance and the dependency ratio. This paper, consequently, should be regarded not as the end but rather the beginning of a new phase of research on the prospects for an extended period of 'lean cows' over the coming decades.

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