LONG-TERM GROWTH AND PRODUCTIVITY TRENDS: SECULAR STAGNATION OR TEMPORARY SLOWDOWN?[1]

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Economic growth in advanced countries has slowed in successive stages since the 1970s and, since the crisis, has fallen to a historical low compared with the 20th century. This slowdown is mainly attributable to weaker growth in total factor productivity. In emerging countries, the situation varies: in some countries, such as South Korea and Chile, GDP per capita have been converging for several decades; in others, such as Argentina, Brazil and Mexico, relative GDP per capita has stagnated or even declined. While weak long-term growth in these latter countries can be attributed to a lack of appropriate institutions, the widespread slowdown observed in advanced countries is more difficult to interpret. One possible explanation that we explore is the decline in real interest rates since the 1990s. A circular relationship appears to exist between interest rates and productivity: productivity determines long-term returns on capital and thereby interest rates; interest rates in turn determine the minimum productivity expected from investment projects. The decline in real interest rates, which is in part attributable to demographic factors, may have led to a slowdown in productivity by making an increasing number of unproductive companies and projects profitable. We illustrate this circular relationship using a cross-country panel regression. One way of breaking out of the circular relationship would be via a new technological revolution linked to the digital economy, or, in countries where there is still room for convergence, via structural reforms to improve the diffusion of Information and Communication Technologies (ICT).

Keywords: growth, total factor productivity, real interest rates, digital economy.

1. The views in this analysis are those of the authors and do not necessarily reflect those of the institutions for which they work.

According to economists such as Robert Gordon, the low GDP and productivity growth observed in all major geographical regions since the start of the 21st century could be a lasting phenomenon (see Gordon, 2012, 2013, 2014, 2015). Gordon posits that the slowdown in productivity is linked to the smaller gains in productive performance derived from today's innovations. Innovations, he suggests, now deliver less growth than the previous technological revolutions, which profoundly changed modes of production and consumption. As a consequence, in addition to the risk of a secular stagnation caused by insufficient demand, as discussed by Summers (2014, 2015) or Eichengreen (2015),[2] there is also the risk of a supply-side stagnation, caused by subdued productivity growth.

This pessimistic vision of future productivity growth has been countered by several economists, including Mokyr, Vickers and Ziebarth (2015), Brynjolfsson and McAfee (2014), van Ark (2016), and Branstetter and Sichel (2017). In their view, the current slowdown is a temporary lull ahead of a sharp pick-up fuelled by the digital economy. Moreover, the acceleration could prove to be particularly strong as it will affect all segments of the economy simultaneously.

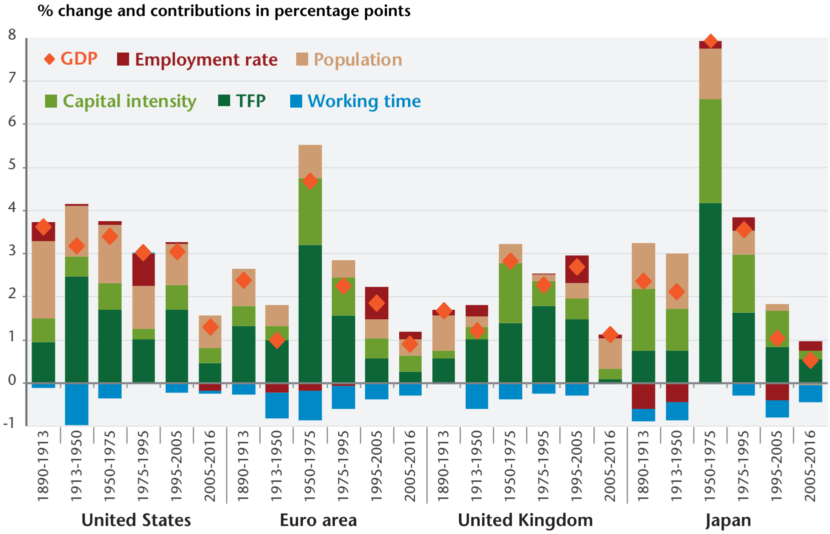
This article aims to revisit the debate over secular stagnation. In section 1 we describe empirically the long-term slowdown in GDP and productivity growth in advanced countries; in section 2 we examine the situation in a sample of emerging countries; and in section 3 we offer various explanations for these long-run trends. Section 4 then discusses the outlook for the future and section 5 concludes.

2. The term "secular stagnation" was first coined by Hansen (1939) to describe the risk of low growth in the United States stemming from a shortfall in demand relative to potential supply. The term was recently reprised by Summers (2014, 2015) to describe the current risk of weak growth resulting from subdued demand. Today's situation is linked to an inability to stimulate demand, both on the part of central banks due to excessively low inflation which is constraining monetary policy (a situation known as the Zero Lower Bound), and on the part of governments due to the poor state of public finances which leaves little room for fiscal manoeuvre. The expression "secular stagnation" has rapidly become widespread and is now used in all approaches studying the possibility of a lasting slowdown caused by insufficient supply or demand.

1. The Decline in Growth is Attributable to a Slowdown in Productivity

Chart 1 provides an accounting breakdown of average annual growth in nominal GDP for the period 1890-2016 in the main developed economies.[3] Five components are identified: population growth, the employment rate (here the number of people in employment as a share of the total population), the number of hours worked, total factor productivity (or TFP for short) and capital intensity. The sum of TFP and capital intensity corresponds to the contribution of labour productivity.

Chart 1. Accounting breakdown of average annual GDP growth from 1890 to 2016



Lecture note: On average, from 1890 to 1913, US GDP grew by 3.6% per year. The contributions to this growth were 1.0 percentage point for TFP, 0.5 percentage point for capital intensity, 1.8 percentage points for population growth, 0.4 percentage point for the employment rate and -0.1 percentage point for hours worked.
Source: Bergeaud, Cette and Lecat (2016); See: www.longtermproductivity.com

Over the entire period and in all geographical areas studied, the strongest contribution to GDP growth comes from hourly labour productivity. Moreover, within hourly labour productivity, the TFP component makes a much larger contribution than capital intensity. It should be noted, however, that the breakdown of hourly labour productivity into TFP and capital intensity is statistically fragile. In

3. This accounting breakdown is based on the usual simplifying assumptions, such as a Cobb-Douglas production function with constant returns where the elasticity of GDP to capital is set at 0.3 for the entire period and for all economies considered. For further details, see Bergeaud, Cette and Lecat (2017).

particular: (i) the weighting applied to the two main factors of production, capital and labour, which is necessary to calculate TFP, relies on major assumptions, notably that this weighting remains stable over time and space; (ii) the volume-price breakdown of investment and therefore capital is based on investment price indices that do not accurately capture gains in product performance and quality, especially in the case of information and communication technologies (ICTs for short);[4] (iii) in order to construct capital stock figures from investment data, assumptions need to be made about mortality rates for different investment components. These assumptions and how they evolve over time are based on incomplete information.

Chart 1 also reveals that TFP and labour productivity have not grown steadily over the period. Several studies have shown that they have in fact increased in a wave-like pattern, and that different countries have emerged as leaders at different times. Moreover, not all countries have succeeded in catching up with the leaders (see, for example, Crafts and O'Rourke, 2013, or Bergeaud, Cette and Lecat, 2016), and the success or failure of this catch-up process depends on interactions between innovation, education levels, and economic and political institutions (see notably Aghion and Howitt, 1998, 2009).

In the United States, three main stylised facts can be singled out concerning the contributions of TFP and labour productivity to GDP growth:

— Throughout most of the 20th century, productivity made a significant and incremental contribution to growth, a phenomenon referred to by Gordon (1999) as “the one big wave”. This wave corresponds to the Second Industrial Revolution which saw numerous innovations, the most notable of which, according to Gordon, were the increasing use of electricity in lighting and motors, the use of the internal combustion engine in industry and transport, the invention of chemicals and notably petrochemicals and pharmaceuticals, and the transformation of information and communication with the dissemination of the telephone, radio, cinema, etc. These new technologies translated into major productivity gains, thanks to an increasingly educated population.

4. See, for example, Byrne, Oliner and Sichel (2013) or Byrne and Corrado (2016).

— The decade 1995-2005 saw a sharp increase in the contribution of productivity to growth. This period corresponds to the Third Industrial Revolution or Digital Revolution, characterised by the diffusion of ICTs. There is ample literature on this phenomenon in the United States, notably Jorgenson (2001), and Jorgenson, Ho and Stiroh (2006, 2008).

— With the exception of the decade from 1995 to 2005, the contribution of productivity to growth has declined steadily since 1950, which explains the slowdown in GDP growth. Various studies have shown that the slowdown observed at the end of the recent period in fact began before the Great Recession (see, for example, Byrne, Oliner and Sichel, 2013; Fernald, 2015; Bergeaud, Cette and Lecat, 2016, 2017).

In the other main economic regions studied here, the wave of labour productivity growth corresponding to the Second Industrial Revolution occurred several decades later than in the United States (although the lag was slightly smaller in the case of the United Kingdom). Moreover, the wave of productivity growth corresponding to the Third Industrial Revolution never actually materialised in the euro area or Japan, and was only felt to a limited extent in the United Kingdom. In these three economic areas, as in the United States, the contribution of productivity has declined steadily but, in contrast with the United States, the decline began after the first oil shock and not after the Second World War. Moreover, the United Kingdom saw a very slight rise in the contribution of productivity to growth in the decade from 1995 to 2005.

These stylised facts have already been commented on (see for example Crafts and O'Rourke, 2013; Bergeaud, Cette and Lecat, 2016 and 2017) and are now widely accepted. The point we need to underline for the purposes of this study is the historically low level of productivity growth reached since the start of this century.

2. Convergence Trends Differ Across Emerging Countries

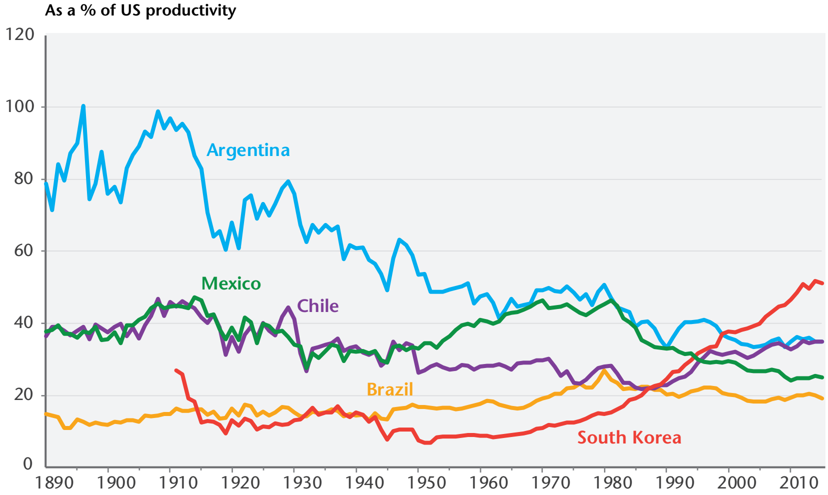
The very low rates of productivity growth observed recently in advanced countries have not been replicated in all emerging countries. In the latter, productivity growth tends to be driven by the process of convergence towards the productivity frontier in developed countries. And this convergence is in turn influenced by institutional factors, such as the educational attainment of the working age population and the quality of existing institutions (for a summary of the literature on this subject, see Aghion and Howitt, 1998, 2009).

A study currently underway[5] has put together comparable productivity series for a number of emerging countries, in particular in South America, using a similar logic as for the developed countries discussed above. Chart 2 shows the level of hourly labour productivity[6] for five emerging countries (Argentina, Brazil, Chile, South Korea and Mexico) relative to that of the United States for the period 1890-2016. As can be seen, the speed and degree of convergence with the United States varies markedly across countries. The following main trends can be observed in relative productivity (i.e. expressed as a percentage of that of the United States): (i) an almost continuous decline over the entire period for Argentina; (ii) a relative stability in Brazil and Mexico over the entire period and, for South Korea, in the period prior to the war at the start of the 1950s; and (iii) a fairly rapid rate of convergence in Chile since the 1980s and in South Korea since the mid-1950s. These differences in trajectories confirm that convergence in productivity levels is not automatic and that the speed and success of the process depend on various factors. Argentina is a particularly interesting case as, at the start of the period, it was one of the leaders and the only country with a comparable level of productivity to the United States. Despite this, it failed to adapt its institutions sufficiently to profit from the growth delivered by innovation: due to strong demographic growth, it had insufficient domestic savings to finance its development when the international financial markets collapsed in the interwar period. As a result, from the First World War onwards, its productivity declined steadily relative to developed countries (see in particular Taylor, 1992, on Argentina, and Acemoglu, Aghion and Zilibotti, 2006, for a demonstration of the importance for growth in frontier countries of having institutions that are adapted to innovation).

5. The sources and methods used for this study are available at the website for the Long Term Productivity project: www.longtermproductivity.com

6. Due to the statistical difficulty of evaluating capital stock in emerging countries, the indicator used here is hourly labour productivity and not TFP. That said, our evaluations of TFP for these countries produce qualitatively similar results (see www.longtermproductivity.com)

Chart 2. Hourly labour productivity relative to US



Source: See: www.longtermproductivity.com

3. Growth in Productivity and Real Interest Rates: A Circular Relationship?

One comment frequently made is that GDP growth (and therefore productivity growth) fails to accurately measure, or even ignores, several aspects of effective growth over the recent period, which is being increasingly driven by the digital economy and by new technologies. A number of studies have focused on this issue in recent years, and all seem to concur that the size of this underestimation has remained fairly stable for several decades and cannot therefore explain the recent slowdown (see, for example, Byrne, Fernald and Reinsdorf, 2016, Syverson, 2016, Aghion *et al.*, 2017, or, on France, Bellégo and Mahieu, 2016). Moreover, this measurement bias is only one of the many difficulties with GDP – traditional measures of economic output also ignore other elements that have become increasingly important in recent decades, such as non-market home production.

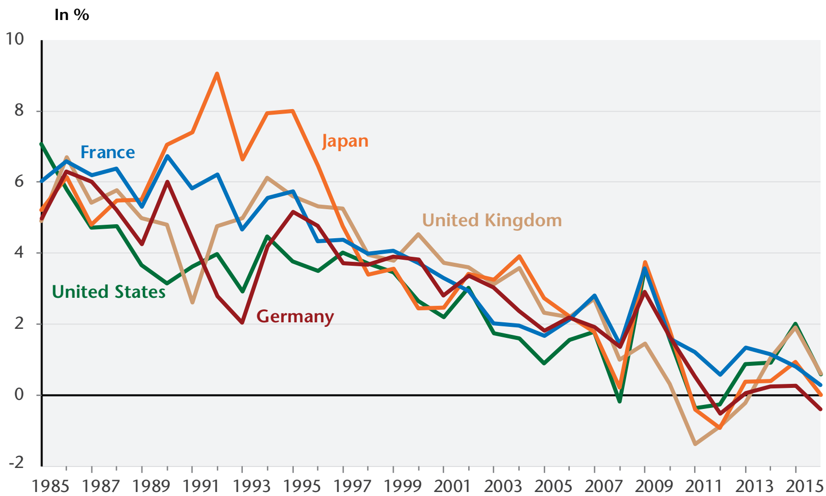
The mismeasurement of GDP does not therefore appear to be the cause of the observed slowdown, and various other explanations have been put forward. Analyses conducted by the OECD on firm-level data, for example, indicate that the global productivity slowdown since the start of the 2000s has not affected frontier firms, and could therefore be explained in part by stalling technological diffusion between these firms and the laggards (see Andrews, Criscuolo and Gal, 2015). This decrease in diffusion could in turn be attributable to various factors, some of which relate to the digital economy: difficulties appropriating certain forms of intangible capital, "winner-takes-all" dynamics in many sectors of activity, etc. However, the study says nothing of the causes of these phenomena, and why they appeared simultaneously in all developed economies, despite marked differences in their respective productivity levels, technological progress, education levels and institutions. Moreover, these phenomena only apply to certain sectors of activity, whereas the observed slowdown extends beyond those sectors that are ICT-intensive.

Recent analyses by Cette, Corde and Lecat (2017) on a vast sample of French firms confirm that the slowdown in productivity in the 2000s does not stem from a loss of momentum at the technology frontier. There has been no visible slowdown in productivity at frontier firms which, for France at least, appears to refute the theory that we have exhausted the potential gains from technological progress. However, the same data also show that there was no slowdown in the convergence of followers towards the technology frontier in the 2000s, which contradicts the theory that there was a decline in the diffusion of innovations between frontier firms and laggards. At the same time, the dispersion of productivity levels appears to have increased, which could point to a less efficient allocation of factors of production towards frontier firms. This problem could stem from the fact that various shocks have made it necessary to reallocate resources (globalisation, emergence of ICTs, financial crisis) but that this reallocation process has been made difficult by existing rigidities.

One explanation for the increase in productivity dispersion could be the steady fall in real interest rates to ultra-low levels. These enable the least productive firms to survive but also make less efficient investment projects more profitable. Chart 3 shows that real interest rates did indeed start to decline in the main advanced countries from the mid-1980s onwards.

The fall in real interest rates from the mid-1980s could indeed have slowed mortality rates for less productive firms (decline in the "cleansing effect"), thereby hampering the reallocation of factors of production to firms at the frontier. Lower rates could also have made it easier to finance less efficient projects, and this combination of factors could in turn have reduced productivity gains. Several studies have provided support for this explanation (see, for example, Reis, 2013, Gopinath et al., 2017, Gorton-Ordonez, 2015, and Cette, Fernald and Mojon, 2016). It is interesting to note that the majority of these studies, in particular those of Reis (2013) and Gopinath *et al.* (2017), have focused on southern European countries (notably Spain, Italy and Portugal) and on the recent period. For the same period (i.e. since the start of the 2000s), the studies find no such relationship between financing and productivity in other countries such as Norway, Germany or France. Moreover, the decline in productivity gains and hence in potential growth is itself a contributing factor behind the fall in real interest rates (for an empirical analysis of this relationship and a summary of the existing literature, see Teulings and Baldwin, 2014, Bean, 2016, or Marx, Mojon and Velde, 2017).

Chart 3. Real long-term interest rates – 10-yr government bond yields



Source: OECD.

Low interest rates thus appear to lead to a fall in productivity which in turn leads to a decline in rates, creating a circular relationship between TFP growth and real interest rates. Only a technology shock could disrupt this downward spiral, but for an economy to reap the full benefits of such a shock, it needs to have the right institutions in place. Not all countries would derive the same TFP gains from a technology shock. Yet, due to capital mobility, all would experience a simultaneous rise in real interest rates caused by the increase in potential growth in those countries that have benefited fully from the shock because they have adequate institutions. Countries with poorly adapted institutions would thus be dually penalised: real interest rates would rise, but they would not profit fully from the acceleration in productivity growth stemming from the technology shock.

In this study, we carry out a model estimation based on this circular relationship, using both macroeconomic data and individual firm-level data. The results of our estimations using macroeconomic data for 17 developed countries over the period 1950-2016 are described in the appendix. These results provide an initial confirmation that a circular relationship exists between TFP growth and real interest rates.

4. What is the Outlook for the Long Term?

The literature generally cites two potential sources of future productivity growth. The first is an acceleration in ICT performance gains and the second the extension of the use of existing ICT performances to other segments of the economy.

Regarding the first source, various recent analyses based on in-depth technological studies of semiconductor manufacturers indicate that there could be significant gains in the performance of these products at various stages in the future: first, in the nearer term, the widespread operational use of 3D chips; second, in the longer term, the harnessing of the potential offered by quantum computing (see summary by Cette, 2014 and 2015) and artificial intelligence (see Aghion, Jones and Jones, 2017).

Regarding the second source, various analyses have stressed that it always takes a long time for the full impact of a technological revolution to be felt in productive activity (see, for example, Brynjolfsson and McAfee, 2014; van Ark, 2016; Branstetter and Sichel, 2017). As Robert Solow famously wrote in a 1987 article in the New York Times,[7] "You can see the computer age everywhere, but in the productivity statistics". This impatience suggests we have forgotten what happened in previous technological revolutions: the profound changes were only

7. Article entitled "We'd better watch out" published in the *New York Times Book Review*, 12 July, 1987.

diffused gradually, and their impact on productive performances was not felt until decades later. David (1990) has shown that between 50 and 60 years passed between the invention of a working electric dynamo in 1868 and its full exploitation in production (in the 1920s to 1930s). The widespread use of ICTs in the most developed countries has clearly had an impact on productivity, but the benefits have so far been limited and the best could yet be to come. All, or nearly all, sectors of the economy could be profoundly affected by the digital revolution. The huge improvements in ICT performance are making it possible to exploit massive databases almost instantaneously (big data) and at the same time are fuelling the development of artificial intelligence. In other words, as van Ark said (2016), the current pause in the productivity gains from the Third Industrial Revolution could in fact be a period of transition between the creation and installation of new technologies and their full deployment. As with previous technological revolutions, notably the invention of electricity, this deployment phase will take time and will require major changes to our institutions and to our methods of production and of management. However, it is already close at hand.

It is still difficult to predict with any accuracy how the digital economy will change productive activity and, more broadly, our way of life. The historical analyses conducted by Mokyr, Vickers and Ziebarth (2015) remind us that forecasts of this type are frequently wrong. At best, we can probably predict what will happen in a few sectors where the changes are already partly visible or imminent. One example, of course, is in transport, where the emergence of driverless vehicles will lead to major gains in productivity, and will completely transform the production of transport equipment, such as cars. These changes will relate not just to the technological content of the equipment itself, but also to the quantities manufactured, as the same needs will be met more efficiently with smaller amounts of materials. In other areas such as banking and retail, similar radical changes are already starting to make themselves felt.

5. Concluding Remarks

There is no real consensus among economists as to the causes of the marked productivity slowdown in advanced economies. However, numerous studies suggest the phenomenon could be temporary and that productivity could in fact accelerate again, although it is still unclear when. According to this hypothesis, a secular stagnation could yet materialise if the conditions are not in place for an improvement in demand. In the euro area, these conditions are particularly difficult to achieve, as they imply genuine economic policy coordination between fiscally independent countries, in a context where weak demand, characterised by high unemployment, is concentrated in certain countries (mainly southern Europe), while the fiscal leeway and current account surpluses are concentrated in others (essentially northern Europe, mainly Germany and the Netherlands). Monetary policy has done a great deal to stimulate domestic demand in the euro area, with the implementation of so-called non-standard tools in the past few years, including the purchase of sovereign debt. But monetary policy is not the only game in town and it certainly cannot make up for a lack of coordination in domestic demand policies. The only way to alleviate this lack of coordination is to stimulate domestic demand in those countries where there is room for manoeuvre, via stronger wage growth or more expansionary fiscal policies (cuts in taxes or hikes in public spending).

With regard to productivity, the euro area undoubtedly suffers from ill-adapted institutions, which are preventing it from reaping the full benefits of new technologies and the associated productivity gains. However, as part of this debate over productivity, another important issue needs to be addressed: the outlook for the euro area as a whole. The bloc's underperformance relative to the United States is not inevitable, but is the result of institutional choices and specific policies. Without important changes in these fields, the euro area will increasingly be left behind by other advanced economies, and will struggle to face the numerous challenges of the future. These challenges, which Gordon (refers to as headwinds 2012, 2013, 2014, 2015), are significant and include population ageing, growth sustainability and the reduction of public debt. Moreover, without sufficient productivity growth to oil the wheels of the economy, the political risks to European democracy would inevitably increase.

References

Acemoglu D., P. Aghion and F. Zilibotti, 2006, "Distance to frontier, election, and economic growth", *Journal of the European Economic Association*, 4 (1): 37-74.

Aghion P. and P. Howitt, 1998, *Endogeneous Growth Theory*, Cambridge, MA: MIT Press.

Aghion P. and P. Howitt, 2009, *The Economics of Growth*, Cambridge, MA: MIT Press.

Aghion P., B. F. Jones and C. I. Jones, 2017, "Artificial Intelligence and Economic Growth", *mimeo*, Harvard.

Aghion P., A. Bergeaud, T. Boppart, P. J. Klenow and H. Li, 2017, "Missing Growth From Creative Destruction", *NBER Working Paper* 24023.

Andrews D., C. Criscuolo and P. Gal, 2015, "Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries", *OECD Global Productivity Forum background paper*.

Arellano M. and S. Bond, 1991, "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations", *Review of Economic Studies*. 58 (2); 277-297, April.

Bean C., 2016, "Living with Low for Long", *Economic Journal* (forthcoming), 126 : 507-522. doi:10.1111/ecoj.12370.

Bellégo C. and R. Mahieu, 2016, "La place d'internet dans la description et l'analyse de l'économie", INSEE, *Coll. Insee référence*, pp. 55-73.

Bergeaud A., G. Cette and R. Lecat, 2016, "Productivity trends from 1890 to 2012 in advanced countries", *The Review of Income and Wealth*, 62(3): 420-444.

————, 2017, "Total Factor Productivity in Advanced Countries: A Long-term Perspective", *International Productivity Monitor*, No. 32: 6-24, Spring.

————, 2018, "The role of production factor quality and technology diffusion in 20th century productivity growth", *Cliometrica*, 12(1): 61-97.

Branstetter L. and D. Sichel, 2017, "The case for an American Productivity Revival", Peterson Institute for International Economics, *Policy Brief*, No. 17-26, June.

Brynjolfsson E. and A. McAfee, 2014, *The Second Machine Age. Work, Progress, and Prosperity in a Time of Brilliant Technologies*, W. W. Norton & Company.

Byrne D. M. and C. A. Corrado, 2016), "ICT Prices and ICT Services: What do they tell us about productivity and technology?", *Economics Program Working Paper*, 16-05, May, The Conference, Board, New York.

Byrne D., J. Fernald and M. Reinsdorf, 2016, "Does the United States Have a Productivity Slowdown or a Measurement Problem?", *Brookings Papers on Economic Activity*, March.

Byrne D., S. Oliner and D. Sichel, 2013, "Is the Information Technology Revolution Over?", *International Productivity Monitor*, No. 25: 20-36, Spring.

Cette G., 2014, "Does ICT remain a powerful engine of growth", *Revue d'Économie Politique*, 124 (4): 473-492, July-August.

———, 2015, "Which role for ICTs as a productivity driver over the last years and the next future?", *Digiworld Economic Journal, Communications & Strategies*, No. 100: 65-83, 4th quarter.

Cette G., S. Corde and R. Lecat, 2017, "Rupture de tendance de la productivité en France : quel impact de la crise ?", *Économie et Statistique / Economics and Statistics*, No. 494-495-496: 11-37.

Cette G., J. Fernald and B. Mojon, 2016, "The Pre-Great Recession Slowdown in Productivity", *European Economic Review*, 88: 3-20, September.

Cette G. and O.J. de Pommerol, 2018, "Dromadaire ou chameau ? À propos de la troisième révolution industrielle", *Futuribles*, No. 422, January-February.

Crafts N. and K. O'Rourke, 2013, "Twentieth Century Growth", *Oxford University Economic and Social History Series*, 117, Economics Group, Nuffield College, University of Oxford.

David P. A., 1990, "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox", *American Economic Review, Papers & Proceedings*, 80(2): 355-361.

Eichengreen B., 2015, "Secular Stagnation: The Long View", *American Economic Review*, *Papers & Proceedings*, 105(5) : 66-70.

Fernald J., 2015, "Productivity and Potential Output before, during, and after the Great Recession", *NBER Macroeconomics Annual*, University of Chicago Press, 29(1): 1-51.

Gopinath G., S. Kalemli-Ozcan, L. Karabarbounis and C. Villegas-Sanchez, 2017, "Capital Allocation and Productivity in South Europe", *The Quarterly Journal of Economics*, 132(4): 1915-1967.

Gordon R., 1999, "US Economic Growth since 1970: One Big Wave?", *American Economic Review*, 89(2): 123-128.

———, 2012, "Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds", National Bureau of Economic Research, *NBER Working Papers,* No. 18315.

———, 2013, "U.S. productivity Growth: The Slowdown has returned after a temporary revival", *International Productivity Monitor*, Centre for the Study of Living Standards, 25: 13-19, Spring.

———, 2014, "The demise of U.S. Economic Growth: Restatement, rebuttal, and reflections", National Bureau of Economic Research, Inc, *NBER Working Papers*, n° 19895, February.

————, 2015, "Secular Stagnation: A Supply-Side View", *American Economic Review*, *Papers & Proceedings*, 105(5): 54-59.

Gorton G. and G. Ordonez, 2015, "Good Booms, Bad Booms", manuscript, University of Pennsylvania.

Hansen A., 1939, "Economic Progress and Declining Population Growth", *American Economic Review*, 29(1): 1-39.

Jordà Ò., M. Schularick and A. M. Taylor, 2017, "Macrofinancial History and the New Business Cycle Facts" in *NBER Macroeconomics Annual 2016*, vol. 31, edited by Martin Eichenbaum and Jonathan A. Parker, Chicago, University of Chicago Press.

Jorgenson D., 2001, "Information technology and the U.S. economy", *The American Economic Review*, 91(1): 1-32.

Jorgenson D., M. Ho and K. Stiroh, 2006, "Potential Growth of the U.S. Economy: Will the Productivity Resurgence Continue?", *Business Economy*, January.

Jorgenson D., M. Ho and K. Stiroh, 2008, "A Retrospective Look at the U.S. Productivity Growth Resurgence", *Journal of Economic Perspectives*, 22(1): 3-24, Winter.

Lewbel A., 2012, "Using heteroscedasticity to identify and estimate mismeasured and endogenous regressor models", *Journal of Business & Economic Statistics*, 30(1): 67-80.

Marx M., B. Mojon and F. R. Velde, 2017, "Why have interest rate fallen far below the return on capital", *Banque de France Working Paper*, No. 630, June.

Mokyr J., Chris V.and N. L. Ziebarth, 2015, "The history of technological anxiety and the future of economic growth: Is this time different?", *Journal of Economic Perspective*, 29(3): 31-50.

Reis R., 2013, "The Portuguese Slump and Crash and the Euro Crisis", Brookings Papers on Economic Activity, 46 : 143-193, Spring.

Summers L., 2014, "U.S. Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound", *Business Economics*, 49(2): 65-74.

Summers L., 2015, "Demand Side Secular stagnation", *American Economic Review*, *Papers & Proceedings*, 105(5): 60-65.

Syverson C., 2016, "Challenges to Mismeasurement Explanations for the U.S. Productivity Slowdown", *NBER Working Paper,* No. 21974.

Taylor A. M., 1992, "External Dependence, Demographic Burdens, and Argentine Economic Decline After the Belle Époque", *The journal of Economic History*, 52(4): 907-936, December.

Teulings C. and R. Baldwin, 2014, "Secular stagnation: Facts, causes, and cures", a *new Vox eBook*, *Vox*.

van Ark B., 2016, "The productivity paradox of the new digital economy", *International Productivity Monitor*, 31: 3-18, Autumn.

Appendix. Estimation of the Circular Relationship Between TFP Growth and Real Interest Rates

Table 1 shows the initial results obtained regarding the circular relationship between TFP growth and real interest rates using macroeconomic data for 17 developed countries for the period 1950-2016. These results provide initial confirmation of the existence of a circular relationship between TFP growth and real interest rates.

The estimated model is as follows:[8]

$$\begin{cases} TXR_{i,t} = \beta_1 . TXR_{i,t-1} + \beta_2 . XTFP_{i,t} + X_{i,t} . \gamma + \varepsilon_{i,t} \\ XTFP_{i,t} = \alpha_1 . XTFP_{i,t-1} + \alpha_2 . TXR_{i,t} + Z_{i,t} . \delta + \eta_{i,t} \end{cases}$$

Where $TXR_{i,t}$ is the level of real 10-year interest rates in country i and year t, $XTFP_{i,t}$ is the rate of TFP growth, and X and Z are vectors for exogenous control variables. Lastly, $\varepsilon_{i,t}$ et $\eta_{i,t}$ are two error terms that include a fixed country effect. $Z_{i,t}$ contains the following control variables: EDUC which is the average education level of the working-age population, here the first-difference of the average number of years spent in school, ICT is the first-difference of the two-year lagged nominal ICT capital coefficient (ratio of nominal ICT capital to nominal GDP), POP is the average population growth in the previous decade and ELEC is the change in electricity output per capita in neighbouring countries five years previously. The control variables included in $X_{i,t}$ are POP35-59 for the population old enough to save (here the population aged 35 to 59 years as a share of the total population) and VARINFL which is inflation volatility (here the variation coefficient) in the five preceding years.

We estimate these two equations separately and using two different methods. First we estimate them both using the dynamic panel method described in Arellano and Bond (1991). The results of this are shown in columns (1) and (2) of Table 1. To correct any potential endogeneity problems, and in the absence of any clear instruments, we use the Lewbel method (2012), the results of which are shown in

8. The list of countries is the same as in Bergeaud, Cette and Lecat (2018): Germany, Australia, Belgium, Canada, Denmark, Spain, United States, Finland, France, Italy, Japan, Norway, the Netherlands, Portugal, United Kingdom, Sweden and Switzerland.

columns (3) and (4). The results are consistent with the theory that there is a positive relation between interest rates and rates of TFP growth, as the coefficients β_2 and α_2 are both positive and significant (except in the estimation in column 2 where the coefficient α_2 is not significant at the standard thresholds).

Table. Results of the model estimations

Dependent variable	XPGF	TXR	XPGF	TXR
Estimation method	Arellano-Bond		Lewbel	
Δtfp_{-1}	0.266***		0.279***	
	[0.049]		[0.047]	
Δtfp_t		0.061		0.304**
		[0.059]		[0.144]
TXR_t	0.089***		0.138***	
	[0.024]		[0.032]	
TXR_{t-1}		0.682***		0.653***
		[0.052]		[0.044]
EDUC	2.809		3.174**	
	[1.789]		[1.403]	
ICT	0.306*		0.279**	
	[0.165]		[0.138]	
POP	1.287***		1.347***	
	[0.221]		[0.185]	
ELEC	0.051***		0.052***	
	[0.015]		[0.012]	
POP35-59		0.073**		0.110***
		[0.031]		-0.035
VARINFL		0.097**		0.055**
		[0.044]		[0.026]
R^2	0.164	0.488	0.158	0.467
Number of observations	986	986	986	986

Note: The values in square brackets are standard errors measured with a variance-covariance matrix that allows "clusters" by country. ***, ** and * correspond to p-values of less than 1%, 5% and 10% respectively.
Columns 1 and 3 show the results of the model estimation using the rate of TFP growth (as a %) as an autoregressive dependent variable, 10-year government bond yields (as a %), the first-difference of the average education level (in number of years) of the working-age population (EDUC), the first-difference of the ICT capital coefficient at t-2 (ICT), average population growth (as a %) in the previous decade (POP), and a first-difference estimate of electricity output per capita in neighbouring countries, weighted by distance, at t-5 (ELEC). Columns 2 and 4 show the results of the model estimation using interest rates as the autoregressive dependent variable, the rate of TFP growth, the share (as a %) of the population aged 35 to 59 (POP35-59) and the volatility of inflation (here the variation coefficient) between t-5 and t-1 (VARINFL).
Data sources: Data on TFP are from Bergeaud, Cette and Lecat (2016, 2018), see www.longtermproductivity.com, 10-year government bond yields and inflation are from the OECD and are extrapolated backwards to 1950 using the work of Jorda, Schularick and Taylor (2017), ICT data are from Cette and Pommerol (2018) and series on electricity output and education are from the sources described in Bergeaud, Cette and Lecat (2017).

These estimations are still preliminary and are shown here for information purposes. Several points can nonetheless be highlighted. First, our model does not include fixed year effects. This choice was made to take into account the effect of global changes in interest rates and TFP, which are precisely the changes that interest us the most (for example, the slowdown in productivity since the 1970s). It is interesting to note that our effect remains significant even when such fixed effects are introduced into the model. The model is therefore robust to the use of these fixed effects for capturing the global economic cycle. Furthermore, our model does not take into account the quality of the financial system or other institutional characteristics, which may appear to be a limitation given the results of Gopinath *et al.* (2017) for example. For the period after 1950, there is no clear evidence that southern European countries are more affected by this link between interest rates, the quality of credit allocation, and growth and productivity. A formal test of this hypothesis, consisting in the insertion of a binary variable taking the value 1 if the country is Spain, Italy or Portugal, and our variable $XPFG_{i,t}$ in the first equation, rejects the idea that our results are only linked to insufficiently adapted institutions and to an inefficient financial system in southern European countries.