THE FOUNDATIONS OF A SLOW GROWTH ECONOMY: GLOBALIZATION AND INDUCED TECHNOLOGICAL CHANGE TOWARDS A KNOWLEDGE ECONOMY[1]

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ABSTRACT. The slow growth of advanced economies since the late 90s is interpreted as the transient and apparent consequence of the discontinuity engendered by the sequence of institutional, technological and structural changes towards a knowledge intensive economy. The origins of such discontinuity can be grasped with an interpretative frame based upon the grafting of the localized technological change approach on the Heckesher-Ohlin model of international trade. This approach enables to identify the gale of information and communication technologies as the result of the efforts to cope with the institutional changes and their effects in terms of a strong bias towards knowledge intensive activities and the decline role of capital in advanced economies. The identification of the bias in technological change provides the tools to understand the determinants of the rapid transformation of the economic and social structure of the advanced economies more and more centered on the intensive use of knowledge as a production factor. The bias accounts for the apparent and transient decline of the rates of growth of output and labor productivity. This interpretative framework enables to grasp the foundations of regime shift in the growth of advanced economies and helps to spell out the significant risks of the dangerous transition to a knowledge economy.

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1.Introduction.

The aim of this interpretative essay is to articulate and apply an analytical framework, based upon the grafting of the localized technological change approach on the international trade literature, able to accommodate the stylized facts that have characterized the persistent slow growth of advanced economies in the last decades. This interpretive framework enables to grasp the role of the institutional change that has taken place in the organization of the international economic system (North, 2005), as the driving factor that induced the radical changes in the technology and in the structure of the advanced economies. This highlights the new central role of technological knowledge as a production factor and suggests that the slow growth is a consequence of the decline of the capital intensity of production processes in advanced economies that will last as long as the transition to the new regime is completed.

The rest of the paper is structured as it follows. Section 2 provides a survey of the key stylized changes that have been taking place in the advanced economies in the structure of both supply and demand and in their institutional setup. Section 3 provides the basic analytical frame with the identification of knowledge a central production factor and its explicit integration into a knowledge production function. Building upon the induced technological change approach, Section 3 articulates the view that the emergence of a knowledge production function in advanced countries is the result of the introduction of a gale of technological innovations directed towards the accrued use of knowledge, the production factor that is locally more abundant in relative terms, with respect to the rest of the world. This pattern contrasts the direction of technological change in industrializing countries directed towards the more intensive use of capital and labor that became relatively more abundant. Section 4 explores the consequences of such dynamics especially on the rates of economic growth of the advanced economies. The conclusions summarize the main results.

2.The stylized facts

Since the last decade of the XX century the growth of output in the advanced economic systems, and specifically in the Italian economy, seems to slow down amid major turbulence and raising concerns. The slowing down of the pace of economic growth takes place in a context characterized by the following stylized facts:

1) Institutional changes in the organization of international product markets. The growing levels of globalization makes the advanced economies more and more open to international trade and exposed to the increasing competitivity of newly industrializing countries that can access the cheap labor available in their internal factor markets.
2) Institutional changes in international financial markets. The drastic increase of the mobility of capital across national boundaries allowed major flows of

capital from advanced countries to industrializing countries providing them with easy access to a large supply of cheap capital.

3) Changes in the internal demand. The domestic demand of advanced economies is moving away from tangible goods and the share of services is increasing. Engel's Law displays its powerful effects with the reduction of the share of tangible manufactured goods and the increase of the share of revenue spent on intangible health, education, communication, and entertainment services.
4) The gale of information and communication technologies (ICT) emerges as the induced effect of the efforts to cope with the changes in the international division of labor and exhibits a strong bias in favor of the increase of the output elasticity of knowledge and the reduction of the output elasticity of capital and non-skilled labor. ICT in fact enable to industrialize the generation, use and exploitation of knowledge.
5) Deindustrialization. The share of the manufacturing industry is declining in advanced economies. Deindustrialization implies the demise of production processes characterized by high levels of capital intensity.
6) Global corporations. The evolution of multinational enterprises into global corporations able to combine the dislocation of manufacturing activities in industrializing countries with the location of knowledge intensive activities in home countries specializing in managing the introduction of new products and their distribution in domestic markets.
7) Human capital intensity in knowledge intensive activities. The manufacturing industry of advanced economies is shifting away from low tech sectors typically characterized by high levels of capital intensity towards high tech sector typically characterized by high levels of skill intensity. The competitive advantage of the manufacturing industry of advanced economies relies more and more on the capability to introduce science-based innovations. The generation of technological knowledge and the eventual introduction of technological innovations command high levels of human capital intensity but low levels of capital intensity.
8) Skill intensity in fashion and luxury products. A large share of advanced economies manufacturing industry is based upon the introduction of soft innovation and high levels of product differentiation in the fashion and luxury industries that are based upon the high levels of skilled labor intensity that are necessary to command the generation of symbolic knowledge.
9) Increasing asymmetries in the labor markets and in the distribution of revenue with the decline of the middle class, reduction of real wages of blue collars and increasing levels of poverty and aggregation of a large minority of affluent workers with high wages.

The reduction of the output elasticity of fixed capital is the key aspect of this broad process of technological and structural change. Tables 1 and 2 summarize the empirical evidence about the dynamics of the share of revenue paid to fixed capital in

a group of leading OECD countries in the aggregate economy and in the manufacturing industry respectively in the years 1990-2009.

Following Euler's theorem the share of revenue paid to fixed capital can be considered a reliable measure of the output elasticity of fixed capital. The evidence shows that the output elasticity of capital peaked in most countries in the late 90s and declined ever since. With respect to the data of the manufacturing industry this process is especially evident and strong in European countries such as UK where the output elasticity declines from the 0.375 in 1997 to a minimum of 0.290 in 2007, Italy where it peaks in 2000 0.464 and declines to 0.350 in 2009, Sweden where it peaks at 0.408 in 1995 and declines to 0.298 in 2009, France where it peaks at 0.375 in 2000 and declines to 0.333 in 2007. Although in other countries such as the US the share of revenue on output is more stable, the evidence of Tables 1 and 2 suggests that a major change has been taking place, especially in the European economies with a significant and drastic reversal of a secular trend in the increase of the output elasticity of capital.

CAPITAL OUTPUT ELASTICITY OF THE PRIVATE SECTOR[2]

Country	United States	United Kingdom	France	Germany	Italy	Japan	Netherlands	Spain	Sweden	Austria	Belgium	Denmark	Finland
Time													
1990	0,415		0,406			0,480	0,440			0,428		0,357	0,390
1991	0,416		0,398	0,364		0,473	0,436	0,484		0,421		0,367	0,350
1992	0,418	0,382	0,395	0,349	0,519	0,468	0,419	0,473		0,410		0,374	0,372
1993	0,421	0,404	0,383	0,346	0,525	0,455	0,417	0,467	0,374	0,400		0,375	0,423
1994	0,428	0,416	0,387	0,358	0,538	0,450	0,432	0,477	0,391	0,402		0,401	0,450
1995	0,425	0,419	0,391	0,358	0,553	0,451	0,441	0,487	0,419	0,416	0,433	0,396	0,461
1996	0,433	0,438	0,385	0,361	0,557	0,455	0,440	0,484	0,390	0,424	0,431	0,393	0,450
1997	0,431	0,433	0,390	0,376	0,553	0,455	0,442	0,471	0,400	0,431	0,435	0,398	0,460
1998	0,417	0,408	0,397	0,380	0,567	0,452	0,430	0,471	0,394	0,431	0,439	0,372	0,467
1999	0,412	0,398	0,391	0,377	0,562	0,458	0,422	0,467	0,407	0,432	0,425	0,369	0,464
2000	0,399	0,382	0,390	0,363	0,570	0,458	0,428	0,467	0,376	0,445	0,431	0,397	0,480
2001	0,401	0,374	0,386	0,365	0,570	0,454	0,426	0,473	0,352	0,450	0,416	0,379	0,474
2002	0,415	0,385	0,382	0,368	0,562	0,464	0,424	0,477	0,359	0,456	0,419	0,372	0,474
2003	0,421	0,394	0,381	0,373	0,557	0,472	0,428	0,479	0,372	0,453	0,430	0,372	0,457
2004	0,435	0,398	0,378	0,393	0,557	0,483	0,431	0,485	0,394	0,463	0,448	0,384	0,464
2005	0,441	0,397	0,375	0,402	0,545	0,481	0,453	0,484	0,395	0,465	0,454	0,380	0,448
2006	0,444	0,407	0,372	0,414	0,534	0,473	0,455	0,484	0,411	0,475	0,453	0,377	0,453
2007	0,441	0,405	0,375	0,420	0,536	0,479	0,452	0,484	0,402	0,481	0,452	0,350	0,475
2008	0,438			0,405	0,523	0,456	0,447	0,484	0,390	0,476	0,437	0,332	0,445
2009	0,452				0,506		0,422	0,501	0,360	0,442			0,390

[2] OECD STAN classification: sum of "C01T05 AGRICULTURE, HUNTING, FORESTRY AND FISHING" and " C10T74X NON-AGRICULTURE BUSINESS SECTOR excluding real estate"

TABLE 2 CAPITAL OUTPUT ELASTICITY OF THE MANUFACTURING INDUSTRY

	United States	United Kingdom	France	Germany	Italy	Japan	Netherlands	Spain	Sweden	Australia	Austria	Belgium	Denmark	Finland
Time														
1990	0,353	0,333	0,347		0,422	0,494	0,381	0,402	0,245	0,360	0,320	0,333	0,255	0,360
1991	0,350	0,306	0,340	0,274	0,403	0,490	0,352	0,383	0,205	0,380	0,304	0,282	0,258	0,287
1992	0,350	0,308	0,331	0,246	0,405	0,480	0,333	0,355	0,203	0,397	0,291	0,287	0,282	0,348
1993	0,354	0,324	0,318	0,225	0,415	0,463	0,345	0,335	0,296	0,423	0,269	0,283	0,274	0,417
1994	0,363	0,350	0,323	0,244	0,433	0,449	0,370	0,356	0,352	0,421	0,287	0,306	0,311	0,432
1995	0,374	0,359	0,338	0,238	0,453	0,455	0,393	0,386	0,408	0,388	0,330	0,341	0,303	0,445
1996	0,383	0,374	0,325	0,238	0,448	0,465	0,388	0,382	0,358	0,400	0,347	0,337	0,287	0,421
1997	0,393	0,375	0,342	0,262	0,442	0,462	0,389	0,377	0,365	0,421	0,369	0,358	0,313	0,440
1998	0,380	0,340	0,363	0,271	0,458	0,458	0,392	0,382	0,373	0,416	0,367	0,360	0,301	0,465
1999	0,382	0,321	0,358	0,264	0,449	0,457	0,387	0,384	0,398	0,416	0,382	0,341	0,301	0,462
2000	0,354	0,302	0,375	0,267	0,464	0,468	0,404	0,396	0,392	0,401	0,411	0,364	0,326	0,491
2001	0,343	0,300	0,366	0,265	0,461	0,439	0,387	0,394	0,342	0,402	0,408	0,332	0,303	0,475
2002	0,373	0,289	0,349	0,267	0,453	0,446	0,374	0,395	0,356	0,411	0,406	0,340	0,313	0,476
2003	0,368	0,283	0,343	0,277	0,433	0,472	0,382	0,389	0,362	0,444	0,402	0,336	0,296	0,462
2004	0,413	0,288	0,338	0,301	0,430	0,486	0,402	0,398	0,380	0,418	0,417	0,362	0,300	0,461
2005	0,434	0,289	0,339	0,320	0,420	0,499	0,432	0,400	0,390	0,409	0,428	0,374	0,296	0,450
2006	0,439	0,295	0,328	0,345	0,422	0,489	0,432	0,407	0,417	0,433	0,449	0,370	0,308	0,468
2007	0,447	0,290	0,333	0,366	0,433	0,500	0,452	0,405	0,409		0,459	0,369	0,288	0,497
2008	0,432	0,309		0,327	0,402	0,478	0,436	0,393	0,351		0,454	0,339	0,296	0,454
2009	0,458			0,212	0,350	0,432	0,371	0,374	0,289		0,400	0,295	0,272	0,336

The evidence has lead to growing concern about the capability of the advanced economic systems to cope with the new competitive environment engendered by the entry of new fast-growing economies in international markets. A large literature supports the view that advanced economies may be unable to retain their levels of revenue and stresses the risks that globalization may cause a pathological decline with growing social and political unbalances.

This view can be contrasted and better assessed when the different aspects of the dynamics in motion are framed into a single and integrated framework that takes into account the central role played by the endogenous direction of technological change and the underlying structural changes.

3. Localized technological change and the role of knowledge as a production factor

3.1. The analysis

The stylized facts that have been highlighted can be considered as aspects of a broader process of radical transformation of the structure of advanced economies brought about by the introduction of new technologies directed towards the use of production factors such as technological knowledge that is relatively more abundant in advanced countries and relatively scarce in the rest of the international economy.

Little attention has been paid to the radical changes in the structure and technology of advanced economic system that paralleled the declining performances of advanced economies. Even lesser attention has been paid to the systematic reduction of investment in fixed capital and the sharp decline of the capital intensity of advanced economies.

Specifically we suggest the hypothesis that a radical technological change has been induced by the out-of-equilibrium conditions of both demand and supply brought about by the new division of labor dictated by the drastic changes in the institutional setup of international product and financial markets.

The new conditions of international product markets had direct effects on the domestic labor markets of the advanced economies with the sharp increase in relative terms of real wages. Increased mobility on international financial markets favored the outflow of substantial amount of capital from advanced economies to the new competitors both via foreign direct investments and credits. The competitivity of advanced economies, as measured by the size of market share, declined and brought about out-of-equilibrium conditions that induced the search for new technologies, which could take advantage from the intensive use of locally abundant production factors.

Advanced economies discovered through the last decade of the XX century and the first decade of the XXI century that knowledge was a major discriminating factor as

the single resource that was relatively more abundant in the advanced economies. Hence globalization and the changing patterns of domestic demand induced the endogenous introduction of technological changes directed towards the intensive use of technological knowledge as a production factor. This approach impinges upon the tradition of induced technological change (Acemoglu and Zilibotti, 2001), quite different from the endogenous technological change of the new growth theory (Aghion and Howitt, 1997).

Specifically the changes in both product and factor markets have determined out-of-equilibrium conditions that induced the endogenous introduction of directed technological change characterized by high levels of skilled labor intensity and low levels of traditional factors' intensity. The endogenous introduction of such directed technological change has magnified, with a meta-substitution process, the standard substitution of both capital and labor engendered by the entry in global markets of new competitors that have access to the large supply of both cheap labor in their domestic markets and cheap capital in international financial markets (Wood, 1994; Lee and Vivarelli, 2004).

Following Schumpeter (1939) the gale of information and communication technologies can be considered as the result of the convergence of a myriad of innovation efforts induced by the need to cope with the decline in profitability engendered by the drastic changes in the conditions of international and domestic product markets. ICT are at the same time the consequence and the cause of increased levels of complementarity and convergence among agents. ICT are the result of the converging complementarity among an array of diverse technological changes including disparate fields as space, electronics, software, fiber optics stirred by the collective efforts of a myriad of agents to cope with the declined viability of the previous technological regime. At the same time ICT provided the opportunity to industrialize the generation, use and exploitation of knowledge favoring the interactions and complementarity among the diverse competences and knowledge of a myriad of possessors and users of knowledge (Antonelli, 2011a).

The emergence, introduction and diffusion of ICT had major effects on the decline of role of fixed capital as a production factor and the increase of knowledge embodied in skilled labor. In this approach the increase in the skill intensity of the production process is indeed brought by the use of fixed capital, as in the hypothesis of capital-skill complementarity articulated by Acemoglu (2002), but is also, and mainly, the result of the substitution of knowledge and hence skilled labor, to both unskilled labor and fixed capital (Antonelli, 2011b and 2012).

The new pattern of growth and change reverses a long term growth trajectory based upon the direction of technological change induced by the fast rates of accumulation of capital. A large part of the XX century has been characterized by the introduction of new capital-intensive technologies and by the secular decline of the user cost of

capital due to the increasing supply of savings and the accumulation of capital. The two dynamics reinforced each other as the introduction of capital-intensive technologies was the result of an inducement mechanism engendered by the decline in the user cost of capital. The increase in the output elasticity of capital and the decline of the user cost of capital lead to increasing levels of capital intensity that in turn favored the accumulation of competence and technological knowledge in capital intensive techniques favoring the eventual reinforcement of the direction of technological change towards higher level of output elasticity of capital (Zeira, 1998).

3.2. A simple analytical frame

The new direction of technological change biased towards the intensive use of knowledge as a production factor can be considered as the typical result of the working of the localized technological dynamics. The localized technological change dynamics is based upon the integration of the Schumpeterian notion of creative response activated by changes in product markets with the inducement mechanism (Antonelli, 2003, 2008, 2011a).

According to Schumpeter (1947) agents try and cope when their performances are affected by un-expected events that engender out-of-equilibrium conditions. Firms try and innovate with the new, unexpected conditions, when the localized context of action supplies adequate support in terms of knowledge externalities. Their reaction, in fact, will be adaptive, with sheer technical changes that consist in standard substitution process in the existing maps of isoquants, when the system does not provide adequate support in terms of knowledge externalities. When knowledge externalities are available, instead, the response becomes creative: agents can actually innovate and change their technologies.

This approach can be successfully integrated with the induced technological change literature. The analytical core of the literature that explores the direction of technological change, recently revived a new wave of contributions, impinges upon the well-known inducement hypothesis. This literature concentrates upon the direction of technological change. It recognizes that technological change is not neutral, as it is currently assumed in standard economics. Technological change is intrinsically biased, i.e. it is either capital intensive and hence labor saving, or labor intensive and hence capital saving, as it is the result of the attempt of innovators to cope with the opportunities and constraints of the factor markets (Ruttan, 1997 and 2001).

More specifically we can identify and retain, within the induced technological change approach, two different arguments. According to the first the rate of technological change is determined by the changing characteristics of factor markets. The tradition of analysis that impinges upon the Hicksian reinterpretation of the hypothesis first suggested by Karl Marx, suggests that technological change is induced by changes in the relative price of production inputs in the factor markets and directed towards the

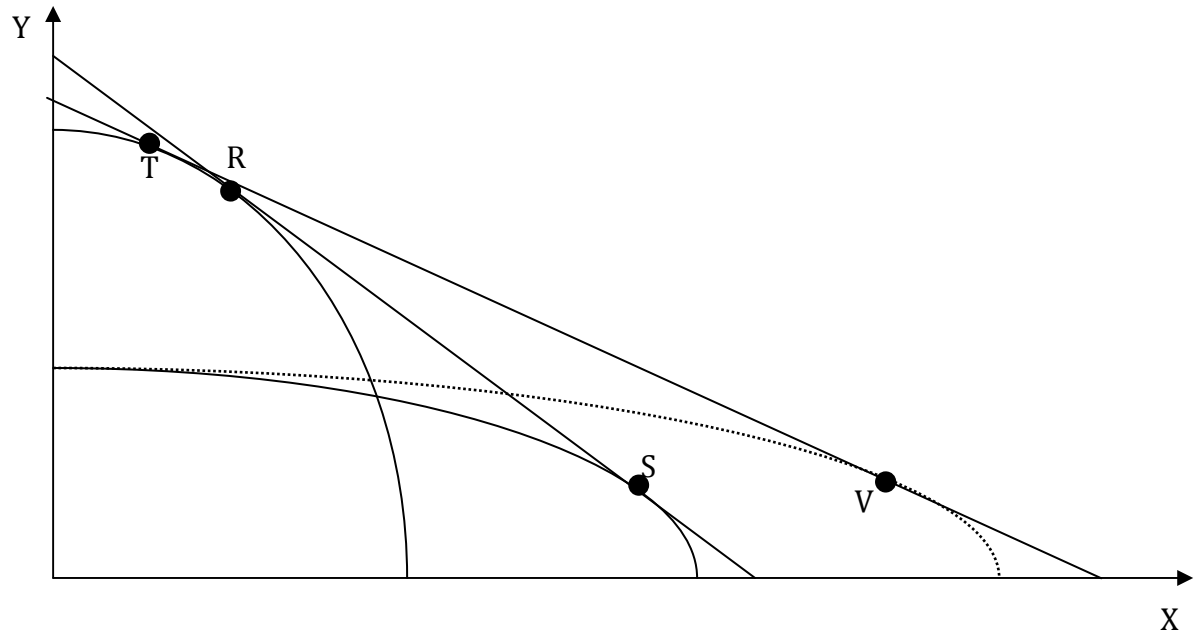
increase of the factor intensity of the production factor that became more expensive (Hicks, 1932; Binswanger and Ruttan, 1978).

The induced technological change hypothesis has been eventually revisited by Kennedy and Kennedy-von Weiszacker who elaborated a very simple model in which the direction of technological change was determined by the efforts to reduce the factor costs that were larger. The model of induced technological change elaborated by Kennedy did not make any reference to the production function framework providing Samuelson (1965) with the opportunity to apply the Euler's theorem and note that the share of revenue paid to each production factor would coincide with its output elasticity. According to Samuelson consequently technological change would be labor saving when the output elasticity of labor would be larger than the output elasticity of capital. The result of Samuelson's point was clearly that in the long run the output elasticity of labor and capital would gravitate towards parity. This brought the induced technological change debate to a long-term forestall.

The localized technological approach attempts to implement the induced technological change approach of Paul David (1975) and puts forth the hypothesis that, at each point in time, technological change is directed towards the most intensive use of the production factor that is locally more abundant enables to articulate a coherent frame of analysis where both product and factor markets play a central role to explain both the rate and the direction of technological change (Antonelli, 2011b and 2012).

Globalization in product markets can be considered as the starting point. The new institutional conditions that have been consolidating since the last decade of the XX century opened the international product markets to firms based in huge, labor abundant economies. The effects of the entry of new labor abundant countries in international product markets can be easily analyzed within the framework provided by the well-known Heckesher-Ohlin model. The integration of new labor abundant countries in international product markets can be portrayed as an increase in the size of the production frontier of labor-intensive products. The consequence is straightforward as it consists in the change in slope of the isorevenue, due to the reduction of the relative price of labor intensive products, the consequent reduction in the equilibrium output of labor intensive products in capital abundant countries and a new international division of labor based upon higher levels of specialization of capital abundant countries in capital intensive products (Antonelli, 2011b; Antonelli and Fassio, 2011).

FIGURE 1. GLOBALIZATION AND SPECIALIZATION



In figure 1 we see that the entry of new labor abundant countries in international product markets affects the shape of the production possibility frontier of the group of labor intensive countries and consequently the slope of the isorevenue: the new equilibrium solutions T and V replace the old equilibrium solutions R and S, respectively in the capital and labor abundant countries.

Globalization affects not only the international product markets but also the internal factor markets. The higher levels of integration of the product markets have in fact the direct effect to change the relative costs of production factors. More specifically it is clear that the entry of new suppliers based in labor abundant countries with low wages has the direct effect to increase the relative cost of labor in capital abundant countries.

In an integrated, open economy the slope of the isocost cannot be any longer determined by the ratio of internal wages to internal capital user costs. The slope of the isocost within the factor markets of an open economy is in fact sharply influenced by the relative levels of internal factor costs with respect to the average levels of the factor costs in all the domestic factor markets that interact and become interdependent because of the open access to the international product markets. The entry of new low wage, labor abundant competitors in global markets reduces the

slope of the isorevenue, hence changes the conditions for the international division of labor and the specialization of countries, and changes the relative conditions of the domestic factor markets.

The appreciation of the notion of relative isocost, as distinct from the absolute isocost, enables to assess directly the effects of the changing conditions of international product markets upon the domestic factor markets of each country that participates into the global economy. Much literature has explored the effects of globalization upon the division of labor and the specialization of countries participating to international trade in product markets. Less attention has been paid to assessing the effects of globalization on factor markets and to appreciating the effects of the relative – as opposed to absolute- abundance of factors upon the dynamics of induced technological change (Antonelli, 2011b).

The entry of the new labor abundant economies into the global economy had the direct effect to reducing the average unit wage within the globalized labor markets so that advanced countries discover that their relative wage are too high. This takes place along a process of drastic changes in their specialization in international product markets with the decline and exit from traditional low-tech sectors and the attempt to try and find new productions that could support a new competitive advantage.

The combination between the induced technological change approach and the Schumpeterian notion of creative reaction fits here. Advanced economies, caught in out-of-equilibrium conditions, were forced to try and introduce innovations to cope with the decline of their market shares and profitability (Schumpeter, 1947). The Schumpeterian reaction is fully consistent with the David induced technological change mechanism based upon the search for a new directed technology able to make the most intensive use of the factor relatively more abundant in the factor markets (David, 1975; Antonelli, 2012).

Firms based in capital abundant countries could face these relative changes in the new globalized factor markets by means of either: a) adaptive responses consisting in textbook substitution moving upon the existing maps of isoquants towards higher levels of capital intensity, or b) creative responses following the localized technological change approach by means of the introduction of new technologies that could help them to cope with the new conditions of both product and factor markets.

The parallel globalization of product and financial markets, moreover, undermined the opportunities for advanced countries to cope with the changes in the international division of labor by means of technical changes, with given technologies. Once again, institutional changes affect the working of the system dynamics deepening the out-of-equilibrium conditions for firms in advanced conomies. The globalization of financial markets plays here a central role. The new international mobility of capital both via

the flows of foreign direct investment of multinational companies and the international finance managed by international banks provided large supply of capital to industrializing companies undermining the viability of their traditional search for a capital intensive bias of induced technological change. Capital was less and less more abundant in advanced economies than in industrializing ones.

The globalization of financial markets made available cheap capital to newcomers. The competitive advantage of advanced economies could no longer be restored by means of structural changes and increased specialization in capital intensive techniques: the system was found farther in out-of-equilibrim conditions. The introduction of radical technological changes became even more necessary. In countries where knowledge externalities were available firms could cope with the negative effects of the entry in international product markets of new, huge, labor abundant ad low wage countries in the global economy by changing their technologies so as to increase the intensity of their production processes in the inputs that were locally relative abundant.

Large firms reacted to the out-of-equilibrium conditions, changing institutional set-up of the international economy with the introduction of the global corporation, as an evolution of the multinational enterprise. The global corporation is the result of a major organizational innovation that reshaped the structure of the multinational enterprise with radical changes in the internal division of labor at the firm level that anticipated the changes in the international division of labor at the system level. Foreign direct investment are no longer directed to displacing exports from home countries, but rather to produce abroad industrial goods and re-import them at home from industrializing countries. The shift to the global corporation enabled to combine the benefits of the location of production in industrializing countries, with the advantages provided by control of distribution chains in domestic markets and the specialization in knowledge intensive activities retained in home countries at the headquarters levels where knowledge is relatively far more abundant. The global corporation is a major organizational innovation induced by the search for larger levels of technological congruence (Caves, 2007; Dunning, 2008).

The notion of technological congruence plays a central role in this context. Technological congruence consists in the matching between locally abundant inputs and their output elasticity. Technological congruence is high when the output elasticity of an input, say knowledge, is large in a country where knowledge is abundant. The application of the notion of technological congruence to an open economy context, yields important analytical results (Antonelli, 2012).

In a Heckesher-Ohlin framework of analysis countries have a clear incentive to make the most intensive use of the production factor that is more abundant in their own factor markets not in absolute terms but in relative ones. Hence David's argument needs to be re-assessed focusing the international factor markets, rather than the

domestic ones. In a closed economy the David argument would have lead to identify capital as the locally abundant production factor. In an open economy context, capital is no longer relatively abundant in advanced economies because of the rapid integration of global financial markets able to supply industrializing countries with large amounts of cheap capital. Hence in an open economy advanced countries have a clear incentive to direct technological change towards the intensive use of production factor that are relatively more abundant in their factor markets with respect to the factor markets of their competitors (Antonelli, 2012).

In advanced countries the search for the identification of the factor that was more abundant in local factor markets with respect to its competitors lead to the identification of technological knowledge as the true production factor that was relatively not only more abundant in advanced economies, but also well rooted and hence with low risks of international mobility because of its intrinsic localization in the complex web of institutions able to interact and valorize the creativity of skilled labor (Antonelli and Colombelli, 20011).

Technological change at the country level mirrored the major organizational innovation, experienced successfully, at the firm level, by global corporations with the twin specialization in manufacturing in industrializing countries and in knowledge intensive activities –R&D, finance, advertisement, marketing, distribution- in advanced countries, at the upstream and downstream ends of the value chain within the global enterprise.

The global enterprise anticipated the specialization of advanced countries in the generation and exploitation of technological knowledge. The activities that concur to the generation and exploitation of technological knowledge became the key sector in the advanced economies with increasing levels of employment and fast rates of growth of output. Major institutional changes parallel the emergence of the new economic activity: new markets for knowledge emerge, academic and public research institutions increase their interactions and transactions with the rest of the economic system, profit-seeking firms specialize in the generation of technological knowledge, knowledge intensive property rights are traded in financial markets, knowledge intensive business services and venture capitalist favor transactions and interactions in the new markets for knowledge (Machlup, 1982; Geuna, 1999; Stephan, 2011).

The decline of profitability experienced in advanced economies as a consequence of the changing conditions of international and domestic product markets induced a generalized and distributed reaction that favored the emerging complementarity among a variety of innovation efforts, mobilizing the knowledge base of many different agents. The result was the gale of new information and communication technologies, characterized by high levels of output elasticity of knowledge and low levels of output elasticity of fixed capita and unskilled labor.

The gale of information and communication technologies that is at the heart of the rate and direction of technological change since the late seventies of the XX century responded to the need to identify and apply technological knowledge as an explicit input into the production process. Information and communication technologies favor the codification of technological knowledge and the organization of the generation of technological knowledge. Information and communication technologies enable the emerging identification of a knowledge industry specializing in the generation and exploitation of knowledge as an economic good. Digital technologies can be considered as the same time the consequence of the induced process of introduction of a new knowledge intensive technology and the cause of the radical process of structural change that is taking place in the production processes and in the factor markets of the advanced economies (Stephan, 2011).

The analysis elaborated so far can be usefully framed with an approach based upon a Cobb-Douglas knowledge production function. The knowledge production function can be considered as a static yet effective representation of the growing intensity of knowledge that is necessary to use because of the underlying intensity of innovation processes. The introduction of innovations requires the generation of technological knowledge. Hence its explicit integration into the production function can be considered as the static reflex of the systematic reliance of advanced economies in the introduction of innovation to retain their competitive advantage on international product markets. The explicit integration of knowledge as a production factor into the production function enables to grasp the effects of the central role of the innovation process, characterized by high levels of skilled labor intensity, and its substitution to capital and standard labor, as the central production factor.

The Cobb-Douglas knowledge production function includes, next to the standard inputs such as capital (K) and labor (L), technological knowledge (T), with their respective output elasticities a, b and g in an open economy:

(1) $Y = K^a L^b T^g$

We assume that in country i technological knowledge is more abundant than in the rest of the international economy where both capital and labor are relatively less scarce than technological knowledge. Hence wages (w) and the user cost of capital (r) are lower in the other economies than in country i, while the cost of technological knowledge (t) is lower in country i than in the other economies. We can identify two cost equations for country i and the other economies (o):

(2) $C_i = r_i K + w_i L + t_i T$
(3) $C_o = r_o K + w_o L + t_o T$
where $r_i > r_o$, $w_i > w_o$, $t_i < t_o$

In a static context, standard optimization suggests that the effects of international competition on product markets are such that in the new division of labor country i will make a more intensive use of technological knowledge, while the rest of the international economy will specialize in techniques with higher levels of capital and labor intensity. In this context, as a matter of fact, the inclusion of T as a production factor before globalization, can be considered as redundant as the role of technological knowledge could be considered as marginal. Its inclusion as a key production factor becomes actually necessary after globalization as the result of a dynamic process of technological change induced by the decline in profitability and markets share (Antonelli, 2003, 2008, 2012).

The parallel globalization of product and financial markets engendered a major shift in the slope of isorevenue plane that identifies the equilibrium solution on an innovation possibility frontier with three production factors: capital, labor and technological knowledge. The induced direction of technological change lead to identify technological knowledge as the key abundant factor in advanced economies exposed to the international mobility of goods and capital and hence to the sharp increase of the output elasticity of technological knowledge and the complementary decline of the output elasticity of both capital and labor.

Country i will be induced to enhance its specialization in knowledge intensive activities beyond the static levels of the existing map of isoquants and will try and change its technology with the introduction of biased technological innovations directed towards a more intensive use of technological knowledge and hence a new output elasticity G for technological knowledge larger than g, the original output elasticity of technological knowledge. Country i finds it convenient to increase as much as possible the intensity of the production factor that is relatively more abundant. In country i technological change will be biased in favor of the intensity of knowledge, the production factor that is locally more abundant.

The new production functions can be specified as it follows:

(6) $Y_i = K^A L^B T^G$

where $A<a$, $B<b$, $G>g$

After the introduction of the new directed technologies the two economies will be far more different, than before. The specialization of country i in the generation, use and exploitation of technological knowledge will be even stronger than before as the substitution process on the existing map of isoquants is enhanced and reinforced by the introduction of biased technologies that favor the more intensive use of technological knowledge.

3.3 Implications

The introduction of new knowledge intensive technology has major implications. First of all it is clear that the new equilibrium conditions of the production processes

in the advanced economies will be found in techniques that are characterized by low levels of capital intensity. In turn the reduction of the capital intensity of the economic activities of advanced economies has major consequences on labor productivity that obviously declines for the lower levels of capital intensity. The generation of technological knowledge is a highly skilled labor intensive activity with little contribution of fixed capital. As a matter of fact labor enters, in the new production function, both as standard labor and skilled labor. The capital intensity of production processes declines both for the absolute decline of the numerator and the decline of the denominator.

The reduction of capital intensity and labor productivity has negative effects on the apparent levels of equilibrium output that in turn declines. From the viewpoint of the performances in terms of output the long term result of the new knowledge economy characterized by very high levels of labor-and-skill intensity and low levels of capital intensity are necessarily lower than the performances of capital intensive economies, simply because of the definition of output in terms of value added. For a given employment, the value added of a software company is necessarily lower than the value added of a steel company. The new production processes are characterized by lower levels of labor productivity simply because the contribution of fixed capital is much lower.

The consequences on the domestic factor markets are quite interesting. As Figure 2 shows, the introduction of the new directed technologies engenders a leftward shift of the derived demand for standard labor. Wages will decline as well as employment. As Figure 3 shows, the derived demand for skilled labor able to contribute the generation of technological knowledge both science based and symbolic, exhibits a clear rightward shift with positive effects both in terms of wages and employment. The share of skilled labor on total employment rises. The wages of knowledge workers become much larger than the wages of blue collars.

Finally, as Figure 4 shows, in the domestic capital markets there is a clear leftward shift of the derived demand for capital and a consequent decline of the interest rates. This process however is fully compensated by the high mobility on international financial markets. Idle capital, no longer used in advanced economies, flows towards the new industrializing markets where on the opposite the demand is growing.

The actual changes in the distribution of revenue in advanced economies, as revealed by the empirical evidence, are consistent with the expectations based upon this simple exercise. The variance in labor markets between the two components, the blue collars and white collars, is one of the consequences of the introduction of biased technological change directed towards the reduction of the use of production factor that are more expensive in advanced economies and the increased use of technological knowledge as a production factor.

The transformation of the technological regime has profound implications. Only after completion of the transition to new technological regime, can the rates of growth of output be restored. As long as the transition is in process, however, it is clear that the rates of growth decline. The output levels that can be produced with the new technological regime are intrinsically lower than in the previous regime. The new technological regime, induced by the parallel globalization of product and financial markets is centered upon the substitution of skilled intensive knowledge generation activities to fixed capital and the complementary employment of workers with low levels of human capital.

The reduction in capital intensity is likely to engender a reduction of labor productivity, even if the wakes of skilled manpower are far larger than the wages of standard labor, and hence in output levels. According to the composition effects, the transition from a capital intensive to a knowledge intensive technological regime may imply a persistent decline of the rates of growth of output, if not an actual reduction of its levels.

FIGURE 2 THE SHIFT OF THE DERIVED DEMAND FOR BLUE COLLARS

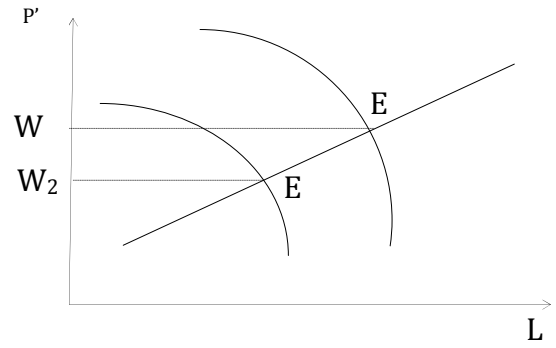


FIGURE 3 THE SHIFT OF THE DERIVED DEMAND FOR KNOWLEDGE WORKERS

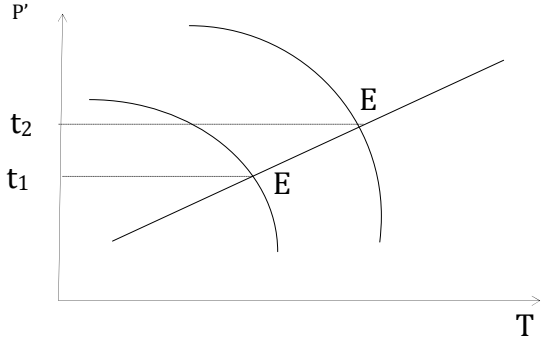
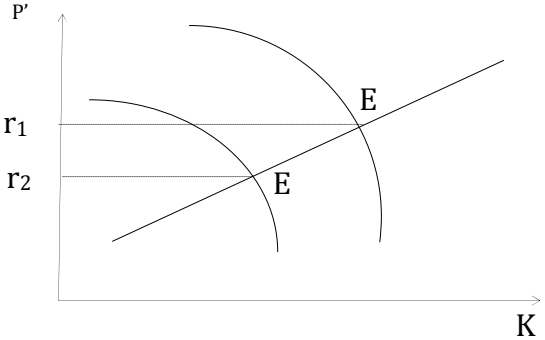


FIGURE 4 THE SHIFT OF THE DERIVED DEMAND FOR CAPITAL



These dynamics are all the more impressive when confronted with the dynamics at place in newly industrializing countries. Here, in fact, the classic inducement mechanisms work along the traditional patterns with the increasing relative abundance of capital and the emerging relative scarcity of labor. International flows of capital provide industrializing countries with a large supply of capital that makes it locally abundant. Technological change is directed towards the introduction of capital intensive technologies. The reduction in the user cost of capital, the increase of wages and the scarcity of technological knowledge favor the introduction of capital intensive technologies. The capital intensity of production processes increases as well as labor productivity. Growth of output is sustained by the fast increase of international demand due to the relatively low wages and the fast rise of the internal demand supported by the fast growth of the demand for capital goods and the ensuing accelerator effect.

While industrializing countries experience a fast growth of output and labor productivity, in advanced countries, the transition to the new production structure is characterized by:

1) a sharp reduction of the aggregate demand because of the decline in investments with a contraction of the derived demand for capital goods and inverse effects of the investment accelerator.
2) a reduction in the internal demand for capital goods with negative consequences for the local markets of the industries specializing in their production and hence the search for new opportunities on international markets to meet the increasing investments of newly industrializing countries,
3) a reduction in the demand for long-term financial capital with the creation of excess finance in domestic markets with the consequent increase in international financial flows to meet the increasing demand for finance of newly industrializing countries,
4) the decline of the derived demand for unskilled labor with consequent mass unemployment,
5) trends towards a possible decline of real wages for blue collars in advanced economies, yet still higher than in newly industrializing countries,
6) the increase in the demand for skilled labor with consequent increase of the wages for white collars with high levels of human capital,
7) the ratio of public debt to GDP increases, the denominator declines,
8) the flow of fiscal receipts declines as a consequence of the reduction of output and labor productivity, while public expenditures increase in the effort to support the transition,
9) The fiscal crisis of advanced economies forces the progressive reduction of the welfare system and the progressive substitution of profit seeking supply of basic services such as health and education to public services.

The transition to the new technological regime engenders a major discontinuity in the rates of growth and requires dedicated and intentional interventions of economic

policy. It should be clear that the slow growth is transient as it is likely to parallel the transition until the substitution of the old regime with the new one is completed. During the transition phase in fact the substitution of capital intensive production processes with skill-intensive ones is likely to affect negatively the rates of both output and labor productivity. When the transition to the new technological and structural regime based upon the intensive use of knowledge as a production factor is completed, the growth of the system will be determined, again, by the increase of total factor productivity and inputs. Hence the slow growth is a transient process, unless the problems encountered to cope with the transition phase do not harm the social structure of the system.

4. Conclusions

This interpretative essay attempts to provide a coherent explanation of the persistent decline in the rates of growth of advanced economies since the late 90s of the XX century. The slow growth of advanced economies is interpreted as the consequence of a regime shift engendered by the sequence of institutional, technological and structural changes in the advanced economies towards a knowledge intensive economy. The persistent decline of the rates of growth of advanced economies since the late 90s is viewed as the consequence of a discontinuity in the structural and technological foundations of advanced economies. The identification of this discontinuity can be accommodated into an interpretative frame based upon the grafting of the localized technological change approach on the Heckesher-Ohlin model of international trade. The apparent decline of the advanced economies can be explained by the new direction of technological change induced by the major institutional changes that have taking place in the international division of labor. The parallel globalization in product and financial markets and the working of Engel's law has induced the introduction of radical technological changes directed to increase the intensity of production factors such as human capital and skilled labor that are relatively more abundant in advanced countries. Saturation of the demand for tangible goods produced by the manufacturing industry and the increasing role of services in final demand have magnified the transition to an economy based upon the production of services.

Elaborating upon the analytical tradition of the induced technological change hypothesis we have elaborated a simple analytical framework based upon the knowledge production function. The appreciation of the increasing role of technological knowledge as an input into the production of other goods enables to specify a production function where the output elasticity of technological knowledge keeps increasing, while the output elasticity of labor declines. For given levels of capital user cost the stock of capital and labor productivity may decline.

The knowledge production function can be considered as static yet effective representation of the growing intensity of the underlying intensity of innovation processes. It enables to stress the central role of the innovation process, characterized

by high levels of skilled labor intensity, and its substitution to capital and standard labor, as the central production factor and to grasp the effects of the new centrality in advanced economies of production processes, based upon the continual introduction of product and process innovations, induced by globalization.

As a consequence of the new centrality of skilled labor, the capital intensity may decline, especially if the decline of capital user cost do not contrast the process engendered by the decline of the output elasticity of capital. The decline of the capital intensity may bear the decline of labor productivity. The decline of labor productivity engenders the apparent decline of value added and hence output.

Both the decline of labor productivity and output however are far from the pathological consequence of a decline of advanced economies. Quite on the opposite they are the consequence of the profound technological and structural change that has been induced by the changing conditions of product and factor markets brought about by globalization. The negative effects are more apparent than real since the decline of labor productivity and output parallel the drastic contraction of the role of capital in the production process. As soon as we regard capital as an intermediary product, instead of a primary production factor, this reduction has no longer effects on the actual levels of output produced. At a closer look it seems evident that for given levels of employment, the substitution of steel mills with software companies, may seem to engender a decline in the standard of living as long as we keep measuring output in terms of value added. As soon as we use a production function that includes two kinds of labor, respectively with high and low levels of skills, and we consider capital as an intermediary input, however, it becomes clear that the reduction of output and labor productivity in only apparent.

The decline in the rates of growth is not only apparent but also transient. Since it is the consequence of the regime shift, it should last as long as the transition to the knowledge economy is completed. When the new knowledge economy will be fully in place, in fact, the rates of growth will no longer be trimmed by the substitution of production processes characterized by high levels of skill-intensity and low levels of capital intensity, to production processes characterized by high levels of capital intensity and hence high labor productivity.

The transition from the economic system that characterized the XX century, based upon technologies with high levels of output elasticity of capital and low relative levels of real interest rates, and hence high levels of capital intensity to the new knowledge based economy, based upon new information and communication technologies, with low levels of capital intensity and labor productivity, can be painful for the working of deflationary dynamics of contraction of the aggregate demand engendered by decline of investments rates and of the demand for capital goods, and the parallel creation of mass unemployment, fall of fiscal receipts and increased fragility of public finance.

The fiscal crisis and the consequent trimming of welfare expenditures on the ne hand and the increasing segmentation of labor markets risk to engender the splitting of the middles class into a clepsydra society constituted by two social groups. A strong minority able to command high levels of human capital with high revenue and the second where the unskilled portion of the middles class risks to face a sharp decline in the levels of revenue.

An active economic policy able to implement dedicated mechanisms of governance to manage this transition is clearly necessary.

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