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MEASURING PRODUCTIVITY IN THE NEW ECONOMY

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Abstract

The neo-classical theory of production identified only two production factors: labour and capital. Paul Romer proposed a change to the neo-classical model by introducing the technology (and implicitly knowledge on which it is based) as an inherent factor of the economic system. The Internet economy offers the possibility to develop the businesses in a totally new way by innovatively using the IT&C. This increase is highlighted by the increase of the Multifactor Productivity in the late 1990's in the USA economy.

„For the leading countries in world economy, the balance between knowledge and resources inclined so much that knowledge probably became the most important factor to determine the living standard, more than land, tools or labour. Nowadays the most developed economies are based on knowledge" [1].

Almost 200 years ago, the industrial revolution replaced the agricultural economy paradigms which had existed for centuries, and then just like today, the change took place almost imperceptibly. As a result of the information revolution, the information era gradually replaces the industrial one.

In the last two hundred years, the neo-classical theory of production identified only two production factors: *labour* and *capital*. Knowledge, productivity, education and intellectual capital were considered as exogenous factors. The economist Paul Romer from the Stanford University, together with other economists tried to explain the causes of a long-term economic growth (exactly what happened in the USA economy between 1980 - 2000) by developing a new theory on economic growth, as the traditional economic models could not coherently explain it. Starting from the results of the models developed by the supporters of the neo-classical theory of production like Joseph Schumpeter, Robert Solow and others, Romer proposed a change to the neo-classical model by introducing the *technology* (and implicitly *knowledge* on

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[1] *World Development Report,1999*

which it is based) as an inherent factor of the economic system. "Knowledge became the third production factor in the most developed economies" [1] .

Romer's theory differs from the neoclassical one in that it establishes several fundamental principles:

- Knowledge represents an important part of the capital. Economic growth is driven by accumulation of knowledge;

- While the neoclassical theory considers any technological development as accidental, Romer thinks that the new technological developments represent the starting point for further innovations and by that it constitutes a main factor of the economic development;

- The technological development can rise the return of investments, which explains why the developed countries are able to sustain the economic growth while the developing countries, even those with unlimited labour and ample capital, cannot attain growth. In accordance with the traditional economic theories there are diminishing returns on investments. The advocates of the new economic growth theory consider that the effects of the non-rivalry and technical platform effects of new technologies can lead to growth and not to a diminishing of benefits in technological investments;

- Investment can make technology more valuable and vice versa. According to Romer, the circle resulting form this statement can lead to a permanent improvement of a country's economic growth rate;

- Romer considers the benefits from licence rights related to new inventions as a factor which stimulates the companies' innovation policy and the investments in technological research and development. The classic economists talk about the "perfect competition" as being an ideal one.

"Knowledge Economy" is that in which the generation and use of knowledge are predominant in creating welfare" [2]. During the industrial era, welfare was created by the use of machines which replaced and multiplied the human labour based on energy consumption. In information era, "workers based on knowledge", the so called "symbol analysts" are workers operating more with symbols than operating machines. Among these, there can be included not only IT&C specialists but also architects, bankers, designers, researchers, professors, political analysts and others. In advanced economies such as that of the USA, more than 60% of workers belong to this category of "knowledge workers".

Why are these technological innovations so important and why didn't they produce a stronger impact on the entire economy? In 1987, the Nobel Prize winner, the economist Robert Solow wrote: "Why the computer revolution is so

[1] Romer, 1986-1990

[2] UK Commerce and Industry Department, 1998.

visible everywhere but in the global economy productivity statistics?"[4]

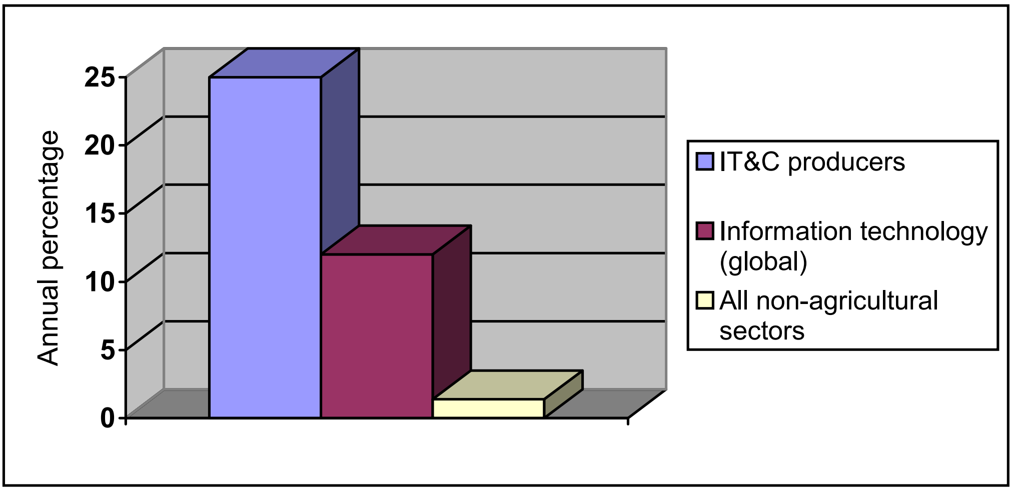
Solow shared the general idea that the IT&C has a high potential to generate an economic revolution. Analysing the economic statistics he noticed a slow increase of productivity at global level.

Fourteen years from the date generally accepted as the beginning of the "deceleration process" in the productivity increase – the year of the great oil crisis of 1973 – until 1987, when Solow formulated the question above, there was noticed an annual growth of 1.1% of the hourly working output in non-agricultural sectors in the USA. As opposed, during the previous fourteen years before 1973, the annual gain in output had been 2.8%. Solow compared this period to the period between 1987 – 1995 and observed a productivity increase of only 0.8% per year in the same economy sectors.

This "productivity paradox" deepened even more at microeconomic level, where the analysts discovered that the investments in the high technology generated substantial productivity increase. The American economist, Erik Brynjolffson emphasized a rate of return on investments in computers and computer networks of over 50% per year.[5] Companies that invested massively in technology and adapted their management in order to use the new technology flourished between 1980 – 1990, while their competitors who didn't invested in this field, lost.

An answer to the "productivity paradox" comes from Paul David, specialist in the history of techniques, showing that the economy needs a rather long period to restructure itself and to fully benefit from the potential advantages offered by the technological revolution. David claims that the American economy needed 40 years to benefit from the productive potential of the "dynamo". Electrical power was discovered in 1880 but experiments lasted until 1920 when there appeared the first signs showing the increase of productivity due to the discoveries of Edison and Westinghouse.

Chart 1: Annual productivity in USA, 1990-1998

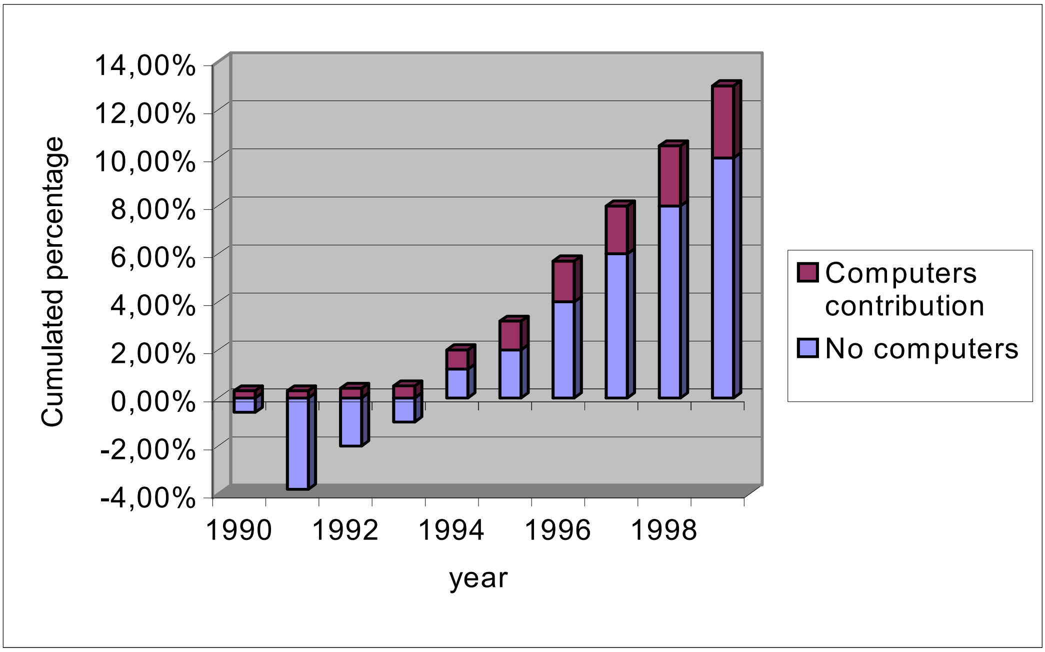


Source: Industry Standard website: http:/www.thestandard.com/

Another possible answer to the „ productivity paradox" is that the specialists in technology and the economic analysts monitoring the global results are analysing two different things. The specialists in technology keep track of the latest innovations in the field and the way they are implemented in the economy. The economic analysts see changes in the global statistics only when the new technologies become common practice. Technically speaking, the same thing happened when both analysts in technology and economy tried to establish the starting point of the industrial revolution. The first took into consideration the inventions and innovations and established 1760 as the starting point, while the second group perceived no significant acceleration of the economic growth until 1840 – 1850 when the results of the industrial revolution were applied on a large scale.

Analysing the GDP per worker in the United States of America in the 1990's, an even more important contribution of the computer technology was observed. Presently, the slow increase in productivity between 1973 and 1995 is considered to have been exceeded due to the IT&C precisely.

Chart 2: GDP increase by worker in USA in the 1990's



Source: Brent Moulton (1999), „GDP and The Digital Economy" (Washington DC: Dep. of Commerce)

These partial answers are not sufficient to explain the "productivity paradox". The only explanation would be that there are systematic losses in estimating the GDP – losses which lead to an over evaluation of the inflation and a under evaluation of the economic growth in the last decades. The signal in this sense was given by Boskin Commission which concluded that there had been made an under evaluation of the economic growth in the last decades by a percentage of 1% to 2% per year – sufficient to double the productivity in 72 years (for 1%), 36 years respectively (for 2%).

The accurate evaluation of the productivity in the fields of education, health, government, public transport and others is almost impossible. The analysts in economics are tempted to assign zero growth for the sectors they cannot assess.

Analysing systematically, the average labour productivity measures the output per unit input that is the production per hour. For example, if a worker used to make a car in 40 hours and now he is making two cars in 50 hours, the productivity increased by 60% from 0.025 to 0.04. The elements generating this productivity can be: more efficient tools, better working conditions, a better organization of work, new assembling technologies, competitive management or other factors. Consequently, the increase of productivity indicates a more efficient use of other production factors, different from the conventional ones which include input of capital and labour.

An interesting productivity evaluation, especially for the estimation of the effects produced by the increasing contribution of the IT&C equipments, the software and other capital investments, is that evaluating the total working hours and also other capital immobilizations. This type of evaluation estimates the increase in efficiency which is not directly due to a large number of working hours or to the operation of a larger number of machines in the production process. This component of productivity is called Multifactor Productivity (MFP). The Labour Statistic Bureau of the United States uses a combination of inputs and capital in defining the Multifactor Productivity. The Multifactor Productivity which indicates the effects of other residual input factors is called Total Factor Productivity, this indicator measuring the output which is not directly due to all inputs (capital and labour) taken into consideration.

A simple mathematic formula is based on the production function:

$Q = A*f(K,L)$, where Q is the output, K is the input of capital, L is the input of labour and A is an amplifying factor.

The output increases by A for a given input of capital and labour.

$\Delta lnQ = \Delta lnA + r*\Delta lnK + (1-r)*\Delta lnL$(r) and (1-r) represent the ratio of capital and labour of the total input, taking into consideration a constant return to scale.

The variation generated by the factor A represents Total Factor Productivity (TFP). In order to calculate the Average Labour Productivity (ALP) which represents the output per working hour, we can express the above equation as follows: $q = Q/H$ and $k = K/H$. The logarithmic expression of these factors per hour becomes:

$$\Delta lnq = \Delta lnA + r*\Delta lnk + (1-r)(\Delta lnL - \Delta lnH),$$

or,

ALP = MFP + capital deepening + labour quality

Capital deepening measures the capital stock per labour hour. Capital deepening makes the workers more productive by offering them a higher investment ratio per working hour.

Labour quality is defined as the difference between labour input increase rate and working hours. In other words, the Multifactor Productivity explains the increase not due to capital deepening and the increase of labour quality.

Previous studies on labour productivity revealed a minimum influence of the information technology on the productivity. Baily and Chakrabarti[1] showed that the "computer experts'" labour productivity did not cope with that of the "productive workers" and they suggested as possible causes the incorrect allocation of resources, problems in production evaluation, redistribution of production within the industries.

The incapacity to identify a positive connection between the investments in the IT&C and the measure of productivity gave reasons to express the well-known "paradox of the IT&C productivity" which in essence claims that "the amazing computers" do not produce significant productivity increase.

New studies indicating a positive contribution of the IT&C to the productivity increase appeared starting with 1986 when Bresnahan' study[2] demonstrated a substantial surplus in the consumer area generated by the investments in the IT&C in financial services sectors. Brynjolfsson and Hitt (1993, 1996)[3] and Lichtenberg (1993)[4] identified significant productivity increase due to capital investments in computers.

Table 1: Average annual contribution in % of IT&C to labour productivity in USA

	1991-1995	1996-1999
IT&C contribution by capital deepening	0,51	0,96
IT&C contribution by MFP increase	0,23	0,49
All other contributions	0,79	1,12
Total	1,53	2,57

Source: Brent Moulton (1999), „GDP and the Digital Economy" (Washington DC: Dep. of Commerce)

A significant increase can be observed in the Multifactor Productivity. It represents the increase of productivity due to inputs other than labour and capital – for example technical and organizational changes, service improvement, process innovations and other similar quality changes. In this sense, the increase

[1] Innovation and Productivity in U.S. Industry ,Martin Neil Baily, Alok K. Chakrabarti, Richard C. Levin *Brookings Papers on Economic Activity*, Vol. 1985, No. 2 (1985)

[2] Quantifying the Competitive Effects of Production Joint Ventures, International Journal of Industrial Organization, Timothy F. Bresnahan, 1986

[3] Brynjolfsson, Erik and Lorin M. Hitt (1996) "The Customer Counts," *InformationWeek*

[4] "R&D Investment and International Productivity Differences," in *Economic Growth in the World Economy*, Frank Lichtenberg (1993)

of Multifactor Productivity in the 1990's in the USA represents a productivity increase due to the use of IT&C in the production sectors.

Undoubtedly, there is no coincidence between the sudden increase of total productivity and the increase of the Multifactor Productivity after 1995 in the USA economy, suggesting the maturation of the Internet and the interconnection of the IT&C applications in the business environment. During the first years, the information technology consisted in the development of very expensive private applications meant to render more efficient the internal activities of companies (sales planning and record, accountancy, reserve management, quality control etc.). In the late 1990's, there could be observed a significant increase of the PC computation power and a development of the interconnection technologies through networks and technologies such as the Internet or World Wide Web.

Nowadays, the IT&C based on Internet not only generate improvements within the companies but also create a new framework for the interaction with the clients, business partners or distribution chain. The Internet economy offers the possibility to develop the businesses in a totally new way by innovatively using the IT&C. This increase is highlighted by the increase of the Multifactor Productivity in the late 1990's in the USA economy.

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