

Таким образом, необходима модернизация российской экономики на основе перехода к инновационной модели развития.

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PIERO MELLA, Full Professor

Department of Economics and Business, University of Pavia

PATRIZIA GAZZOLA, Assistant Professor, PhD

Faculty of Economics, Insubria University

THE DRIVERS OF PRODUCTIVITY

The paper is to demonstrate that productivity is the basis of all productive systems, which are viewed as transformers of utility and value, since the search for maximum productive efficiency is necessary to reduce production costs and thus produce value. After presenting a coherent frame of reference, the drivers of productivity are examined and then the consequences of the continual growth in productivity are discussed as well as non-economic aspects are linked to the gradual improvement in productivity.

Досліджується продуктивність як основа всіх виробничих систем, які розглядаються в якості трансформаторів корисності та цінності, оскільки пошук максимальної ефективності виробництва необхідний для зниження витрат виробництва і, таким чином, отримання цінності. Після аналізу літератури розглянуто драйвери продуктивності, проаналізовано наслідки постійного зростання продуктивності, а також проведено зв'язок між неекономічними аспектами і поступовим підвищенням продуктивності.

Исследуется производительность как основа всех производственных систем, которые рассматриваются в качестве трансформаторов полезности и ценности, так как поиск максимальной эффективности производства необходим для снижения издержек производства и, таким образом, получения ценности. После анализа литературы рассмотрены драйверы производительности, проанализированы последствия постоянного роста производительности, а также проведена связь между неэкономическими аспектами и постепенным повышением производительности.

Keywords: productive system, productivity, drivers of productivity, hypothesis of increasing productivity, employment, jobless economy, JEL classification: D24; L23; M11.

1. Introduction. Productive Efficiency and Productivity

The European Commission communication to the European Council and Parliament of 21 May 2002, whose object was: Productivity: the Key to Competitiveness of European Economies and Enterprises provides this definition: «In formal terms, labour productivity is the quantity of labour required to produce a unit of a specific product. In the macroeconomic context, labour productivity is measured as a country's gross domestic product (GDP) per capita of employed population. Productivity growth depends on the quality of physical capital, improvements in the skills of the labour force, technological advances and new ways of organising. Productivity growth is the principal source of economic growth» [9].

If we let « π_L » stand for the average productivity of labour (L), the COM definition indicates the efficiency in the use of the labour factor, which is directly quantified by the ratio:

$$\pi_L = \frac{QP}{QL} = \frac{QP}{qL \cdot QP} = \frac{1}{qL}, \quad (1)$$

where QP is the volume of production and QL the quantity of labour.

I define productive efficiency as the capacity of the productive system to reduce the unit factor requirements and productivity as the capacity of a productive system to maximize the quantity produced with the minimum use of labour.

If we let « π_F » stand for the average productivity of a generic factor «F» (used in a productive system for a defined period and under unchanging conditions) and generalize the above definition, then productivity is measured through the following relationship:

$$\pi_F = \frac{QP}{QF} = \frac{QP}{qF \cdot QP} = \frac{1}{qF} \quad (2)$$

which immediately shows that productivity is entirely equivalent to productive efficiency.

The search for increasingly greater levels of productive efficiency (and thus labour productivity) is undertaken by all production organizations or firms, since:

- as (2) clearly shows, the more productive efficiency increases, the more production costs fall (the unit requirements, qF , fall), with supply prices held equal;
- alternatively, we can neutralize the increases in the factor prices in order not to reduce EBIT;
- the lower production costs allow firms to obtain higher levels of EBIT even without increasing selling prices;

▪ firms can maintain or improve the levels of EBIT also by reducing the selling prices, thereby undertaking a strategy for increasing demand and reducing potential competition.

In fact, all production organizations pay particular attention to the trends in labour productivity. «The ability to obtain more output from given inputs of labour and capital corresponds to growth in productivity. Productivity growth depends on the quality of physical capital, improvements in the skills of the labour force, technological advances and new ways of organizing these inputs. Historically, productivity growth has been the principal source of economic growth. It has made possible an expansion of output, not just without concomitant increases in inputs, but with important reductions in hours worked over the medium term. In doing so, it has made a sustained rise in real incomes possible» [10].

We can argue (as observation will prove) that in an economic system with a developed network of production firms, each productive organization has a higher probability of long-term survival if it produces at levels of productivity at least equal to those of other firms; in fact, to survive, each production firm must try to improve its efficiency, and thus its productivity levels [14].

This general behavior of every productive organization results in the continual increase of overall productivity in the system, thereby triggering a positive feedback that leads to an increasing trend both in the firm's micro behavior as well as in the system's macrobehavior [14].

This increase in productivity becomes the dominant phenomenon in the entire economic scenario and ends up becoming institutionalized; so much so that I would not hesitate to describe it as a true hypothesis concerning how economic man behaves.

Hypothesis of increasing productivity: the network of production enterprises tends to achieve increasingly higher levels of productivity, but it is governed in turn by this continual increase in productivity.

I have tried to provide an operating justification for this hypothesis by demonstrating how, from a typical holonic viewpoint, this increase in productivity derives from the activities of production firms as a global production network, the productive KOSMOS [15].

2. Explaining Productivity. The Intrinsic Drivers of Productivity

There are two questions which arise when analyzing the increasing productivity of labour:

▪ what does the increase in productivity in individual productive systems depend on? This leads us to search for the factors of productivity;

▪ what do the trends in the productivity of the entire economic system depend on? This leads us to examine the motivations behind the continual increase in productivity.

In order to answer the first question – what does the increase in productivity in individual productive systems depend on – we shall use the term drivers of productivity to refer to those elements, phenomena, causes or variables that can produce an increase in QP and/or a reduction in QL.

Though varied, the drivers of productivity can be grouped into a few categories which, though they interact, must be kept separate in order to facilitate our observation, which is derived from Adam Smith's famous example of the manufacture of pins to illustrate the advantages of the division of labour. «This great increase in the quantity of work, which, in consequence of the division of labour, the same number of people are capable of performing, is owing to three different circumstances; first, to the increase of dexterity in every particular workman; secondly, to the saving of the time which is commonly lost in passing from one species of work to another; and lastly, to the invention of a great number of machines which facilitate and abridge labour, and enable one man to do the work of many» [18]. Following Adam Smith, the authors propose this typology:

1. Passive drivers: these increase QP with QL held constant. There is only one passive driver of productivity: fertility, in all its forms: the fertility of land, water, subsoil; and natural fertility (the banks of the Nile) or artificial fertility (irrigated and fertilized land);

2. Active drivers: these reduce the QL needed to produce, with fertility held constant; there are three types of active drivers of productivity:

▪ Skill; it is easy to imagine that a skilled fisherman or hunter can obtain the same amount of goods in less time than other, less-skilled producers; obviously, applying the same amount of labour as the others, they can obtain a larger quantity of products.

▪ Equipment; from the first chipped rock to modern machines and digitally-controlled plants, equipment extends the capacities of «human hardware» (represented by our body, its limbs, and our brain), reducing the effort and danger associated with production while at the same time rewarding skill. Holding the amount of labour employed constant, we can greatly increase the amount of clothes produced by using a loom rather than a crochet needle; with labour hours held constant, we can increase beyond measure the amount of arable land by using a modern-day tractor, which uses a six-bladed plough, compared to what we could obtain with a single-bladed plough pulled by a pair of oxen. It is easy to imagine how few cars would be produced without the modern robotized assembly line;

and the construction of three pyramids with the limited equipment at the time required more human labour than the construction of all of Manhattan's skyscrapers put together. We can easily recognize the progress computers and robots have produced until now and will continue to produce going forward.

- Specialization; a characteristic of the organization is the functional division of labour; this means that each worker in the organization provides his skilled and equipment-aided labour to undertake a specific activity. This specialization, together with the equipment available, further increases productivity.

3. Endogenous or psychological drivers: these are the psychological conditions that lead man to supply his labour to a given organization; these drivers can be divided into the following:

- Motivation; man is willing to supply his labour only if adequately motivated and if there are expectations that this will satisfy his needs or motivations. At one time the main motivation was pay, either in the form of wages, salary or profit; today other motivations, intellectual in nature, have been added to monetary payments: a job that gives satisfaction is often preferable to a better paid but boring one. Motivation drives man not only to be more efficient but also to continually learn to improve his preparation. Motivation not only is linked to a worker's personal and family situation but also depends on individual «vision» (improving one's status) and the collective culture (advance the group, the homeland, etc.); this driver also includes the worker's ethical attitude toward his role in production and toward time-wasting;

- Satisfaction; motivation provides work incentives to man; the initial motivations must be followed by satisfaction; that is, the satisfactory achievement of motivations.

I shall define intrinsic drivers as those drivers listed above; these directly improve the worker's performance.

Maximum productivity occurs when skilled, equipped and organized work, properly motivated and satisfied, is supplied in a fertile environment: that is, when production is organized into productive systems within production firms and enterprises.

The primary challenge to developed economies will be to create the endogenous drivers of productivity; that is, to motivate and satisfy workers.

Certainly the problem for the future (which already today has become a crucial point) will be to improve productivity through the quality of both products and working conditions.

3. The Extrinsic Drivers of Productivity

Along with these traditional intrinsic drivers of productivity, we can identify other, extrinsic drivers, so called because they involve the organization of productive systems, the environment within which the work is carried out, and, in the final analysis, the firm's policies regarding increased productivity. These differ depending on the type of productive sector and the type of production; among the most important are the following (for a more in-depth economic and historical treatment, see the vast literature on this subject-matter):

- Continual mechanization. Mechanization began with the origins of man himself, with the natural creative capacity of the worker to produce equipment, a capacity subsequently passed on to the organization as a unitary system. In recent years this process has accelerated due to electronic and computer technologies.
- On-line automatic control systems for processes. One of the factors that slows down work is the control function. Mechanization and electronic technologies have automatized the control of processes, with a noticeable increase in labour efficiency in the productive system.
- Work environment: ergonomics. A well-equipped and ergonomic work environment speeds up the execution of tasks to the advantage of productive efficiency.
- Advanced information systems and dematerialization. Making information gathering and access to data bases immediate, thereby increasing their quantity and variety, improves the decision-making process, facilitates the execution of tasks, and avoids errors that require control, with a consequent savings in labour time in every phase of the production process.
- Standardization and use of new materials. Designing products and processes based on unified criteria, utilizing materials and components with specific pre-defined (and thus interchangeable) standards conceived and designed to make the processes they are used in more efficient, speeds up assembly work and makes it more precise, while also reducing quality restoration measures, thereby increasing the productivity of the entire production system.
- Increase in the speed of processes through: (a) streamlined production and the continual improvement and rationalization of the flow of component assembly through the search for total quality and the application of just in time [11]; (b) the rationalization of logistics and of materials handling [5].
- Outsourcing and decentralizing the search for productivity to more efficient units [16].

▪ Progress in scientific and technological research, in particular the development of systems of energy supply and the productive use of energy, as masterfully demonstrated by Carlo Maria Cipolla in *The economic history of World population (1962)* [8].

The improvement in productivity increases welfare [1], which we can see not only in the spread and accumulation of wealth among consumers but also, and perhaps above all, in the gradual reduction in labour times and the improvement in working conditions [4].

We can add to our hypothesis about the increase in productivity by also including in it the continual increase in quality:

Hypothesis of increasing productivity and quality: the network of production firms tends to achieve ever greater productivity and ever higher levels of quality but is itself governed by the continued increase in productivity and quality [15].

4. Several Non-Economic Aspects of Productivity

The search for productivity has such vast and various consequences on the socio-political environment that a systematic analysis, no matter how concise, would go beyond the limits and objectives of this short paper.

Undoubtedly the most significant effect in terms of productivity is the institutionalization of «property». This institution is linked mainly to the discovery of fertility and the invention of equipment, and its aim is to protect the owner's use of the latter.

It seems reasonable that whoever discovers a lake teeming with fish or land well-irrigated by natural waters will supply his labour to such contexts; it is equally natural for the discoverer to try to gain exclusive advantage from the fertility by blocking others from benefitting from it. Anyone who uses his labour to construct a machine will obviously try to stop others from appropriating it.

Deriving from the need to benefit exclusively from such factors of productivity, property has become one of the most deeply-rooted institutions of any time or place in history. We need only remember that one of the Ten Commandments, «Do not steal!», is right next to that which says «Do not kill!». We cannot claim that property – whose genesis and survival is probably also due to the territorial instinct characterizing the behavior of all higher-order animals – is a direct consequence of the production phenomenon, since this institution also arises in areas where self-production exists to protect habitations and furnishings, the factors of production (cattle, stocks, etc.) and the factors of consumption.

Nevertheless, the fact remains that where production is lacking, or in ecological systems where it is confined to self-production, property is

limited only to factors of consumption. Property did not exist in the natural environments among the Indians before they came into contact with white men, or among present-day Pygmies, if we exclude equipment needed for self-production or consumption processes. Similarly, there is no property in communities with exclusively salvific aims, such as Catholic monasteries or Buddhist communities. Property has given rise to, or at least greatly advanced, other phenomena: political institutions (the clan, tribe, state), theft, the administration of justice, wars of conquest and, above all, heredity.

Today the idea of property itself is widespread in all areas («Don't enter my study and don't use my computer», says the employee, even though the property claimed is not his) and often confused, or coupled with, the idea of possession (my institute, my factory, my custodian, my errand boy, etc.).

No less remarkable are the socio-political aspects linked to the other factors of productivity.

For example, the search for skill, its improvement and preservation-transmission gave rise to the great education process, a form of transmission of knowledge, which has evolved from the mere observations of the apprentice in the master's workshop to the advanced post-university and company training courses of today. Skill is the source of greater productivity. As a result, along with the need for professional instruction is that for confidentiality, secrecy or, at least, the right to exclusivity; and thus the need for corporations and certified proof of skill (from Giotto's O to present-day state exams, from aptitude tests to job competitions) and patent offices. However, the aspect of skill that interests us here is specialization, since it is this factor that has brought about the transition from a self-producing and consumption economy to one of production and exchange.

Functional specialization is one of the factors that has most influenced the rise of productivity following the systematic spread of equipment-aided labour initiated by the Industrial Revolution, even if specialization has an easily intuitive «social cost», masterfully illustrated in the memorable 1936 film «Modern Times». Specialization not only involves production operations but production enterprises as well; in particular, it facilitates the creation of enterprises that produce only equipment, components and components of components, etc., to be exchanged with factors of consumption obtained from other enterprises.

Nevertheless, we must keep in mind that, if on the one hand specialization is the result of the need for increased skill levels, on the other the introduction of equipment has made it to a large extent detached

from skill, though still remaining a factor that can increase productivity. In fact, in many ways specialization has ended up making skills easily transferable, even superfluous in some cases.

Equipped labour has for many generations been confined to a secondary role; only with metals technology has equipment been able to bring an improvement to productivity by initially supporting skill until eventually transcending it.

Whereas a hard-earned skill is needed to till the land with an oxen-plough, to use a six-bladed plough pulled by a modern, air-conditioned tractor requires a short training course and special operator's license.

If the blacksmith needs considerable skill to mold the blades of a scythe, to use an automatic scythe that can make 3,000 cuts an hour would probably require only a brief training course. The need for equipment-aided labour has considerably spurred, if not originated, technological research and the associated scientific research. It is impossible to say for sure whether the growth in technology and the flourishing of science is the cause or consequence of the factors of productivity and equipped labour, especially since the three phenomena – together with many others mentioned above – are interrelated in a unitary system of action and of economic, social and political thought.

I shall only observe that in ecosystems where technology is absent or rudimentary production has not developed, the converse is also true. As mentioned above with regard to property, in such situations the economy is centered around self-production.

It has only been a few generations, since the Industrial Revolution, that capital has been used on a large scale. For ages man has searched for equipment to increase the productivity of manual labour; it is only relatively recently – if we leave out the abacus – that computer technology has developed to provide us with instruments than can increase both the productivity of intellectual labour and that of equipment. The age of the robot is about to begin.

5. Tendency for Productivity to Increase

Let us now consider the second question raised in section 2.

The increase in productivity is continual and has an exponential trend, which is certainly correlated to the extrinsic drivers of productivity. Even if the expansion in productivity has been slow and, what is more, has only consistently occurred for what historically is a relatively short period of time, today it is undergoing an amazing acceleration, spreading wealth to all areas, reducing individuals' needs and satisfying their aspirations.

The theory states, and observation confirms, this fact. Productivity appears to be the fundamental variable that allows us to observe the productive system as a single, complex, self-regulating network [15] where economic units, motivated by wealth, and thus profit, achieve incremental progress in productivity in order to remain essential.

But no matter how vast the wealth produced, how large the quantity and quality of needs that «productive man» is able to satisfy, the rationale behind production implies that productivity must continue to advance, while the profit motive makes such progress vital for enterprises.

The Hypothesis of increasing productivity and quality operates inexorably: the increase in productivity, as a general tendency, is inevitable in that it is part of the logic of production itself.

Is there evidence that such an era is approaching? In principle the answer can only be 'Yes'. Scientific research and technological progress, made possible and necessary by the need for increased productivity, have reached such levels as to foresee an extreme increase in productivity: zero-cost productivity.

At a theoretical level, both Alain Turing – the creator of the universal Turing Machine, an abstract computing model that can carry out any properly codified algorithm whatsoever and even reproduce itself – and John Von Neuman – who, with the aim of designing a universal constructor, created Cellular Automata, logical machines that can self-reproduce (at least in theory) and solve computational problems – have demonstrated the possibility of achieving self-replicating automata.

On an applied level, the science and engineering of systems has led to the creation of robots that can carry out complex, system-guided activities (which do not even have to be that sophisticated) involving electronic data processing that make production processes increasingly efficient [6;7], along with a parallel development in artificial fertility (biotechnology) [12].

There are around one million industrial robots in use in factories around the world, in repetitive and dangerous work environments. “In terms of units, it is estimated that the worldwide stock of operational industrial robots will increase from about 1,020,700 units at the end of 2009 to 1,119,800 at the end of 2013” [17].

The entire World Robot Population will reach 8.6 million, and it is not pure fantasy to believe the production of robots will be carried out by robots themselves as part of a close-looped technological chain that produces a positive feedback for continued technological improvement.

It appears that strenuous, and thus tedious human labour, both mainly manual as well as intellectual, will be replaced before long by

mechanical operations. Thus, the active factor of productivity appears to be less and less necessary for production. In principle, even fertility may lose its role as a factor, even a passive one, of production. In fact, fertility is justified when the abundance of resources in certain areas allows labour to be saved and/or production to be increased. When only machines are used to search for and utilize natural resources and labour time no longer represents a cost parameter, then even fertility will become only a distant memory of man's condition of need.

6. Conclusion

The continual activation of endogenous and exogenous factors of productivity will produce increasingly higher levels of productivity and a gradual reduction in the amount of labour needed to obtain the goods necessary for our existence.

Already today the reduction in labour can easily be seen in the following phenomena:

- an increase in the age when people begin their working activity (raising of the age for compulsory schooling, increase in schooling, etc.) [13]
- a reduction in the age when work activity ends (retirement)
- a reduction in the average annual working days (longer holidays)
- a reduction in the average daily work hours (shortened work week)
- an increase in non-employment (unemployment, delayed employment, and layoffs due to redundancy).

The increase in productivity makes wealth more abundant, while also translating into a gradual reduction in the labour needed to produce.

If the increase in productivity over time represents a trend (hypothesis of increasing productivity) and the increase in wealth is viewed as progress, how then can we counter the fall in the quantity of labour needed for production and ward off the fear of the jobless economy?

Although some have a pessimistic view of globalization [2; 3], this phenomenon is developing rapidly, with the economy as a whole becoming a network of interconnected organizations that form a unique global production system. The world of the networks is developing. The computer revolution has only just begun, and its development is unpredictable. The economic system is increasingly more integrated: firms and manufacturing companies form a single, interconnected network [15].

The only firm in existence will be the entire network, which in spite of everything will also be governed by the law of increasing productivity.

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