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Understanding the New Service Economy: Economics, Technology and Risk Management

by Orio Giarini* and Patrick M. Liedtke**

Much has been reflected on the phenomenon of the so-called new economy that has reinforced global co-operation (globalization), challenged traditional business models (Schumpter's destructive creativity), pushed productivity and GDP growth rates in certain regions in the world to higher levels than in the proceeding two decades and resulted in much hyped new evaluation models for judging the value of modern companies. At the root of this phenomenon lies the better understanding of how technology drives the economy, how the new economics allow us to use the right ingredients and processes to create more wealth, and how all this can be managed more efficiently when examining the risks involved.

Unfortunately, many of the approaches to the new economy are just the same old ideas wrapped in new clothes: after all, it is reasoned, the new economy is the same as the old, only that the objects of interest are becoming (or have become) immaterial. We can hence apply the same logic to what is going on nowadays, provided that we adjust a little bit here and there. Yet the authors are convinced that this is not an adequate approach. We will explain our understanding about the real forces of the new economy, naming it consequently the new Service Economy, and the role that economics and technology play together with the need for a modern comprehensive risk management.

1. Today's technologic and economic considerations

The economy and with it the theory of economics have evolved after and as a consequence of the Industrial Revolution.[1] In the new Service Economy, the older concepts are to a large degree no more valid and have to be replaced. The understanding about what is different in the new Service Economy is fundamental. The central points are:

- Services dominate all economic production sectors. Value is related to the performance of a product or service system over a period of time. The costs of production are distributed from the first initiatives (R&D) up to the disposal or elimination of the products or systems.
- Productivity becomes a synonym of quality and performance in time. The cost–benefit ratio takes into consideration R&D, manufacturing, distribution, utilization and disposal costs, while the benefits are measured by the performance during the period of utilization.

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* Editor-in-Chief of *The Geneva Papers on Risk and Insurance – Issues and Practice*, and Director of the Risk Institute.

** Secretary General of the Geneva Association and Director of the Applied Service Economics Centre (ASEC).

[1] O. Giarini and P. Liedtke. The Employment Dilemma and the Future of Work.

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- The volume of remunerated work in the manufacturing activities diminishes as a consequence of new technologies. Growing importance and complementarity of non-remunerated and self-productive work, particularly during system utilization as an element of performance optimization. Trends towards regionalization and decentralization.

Up to now and during the course of the Industrial Revolution, monetarized, paid work, mostly in the manufacturing industries, was the key and practically the only fundamental reference for economic development. Even the "traditional" subdivision of the economy into three sectors at the beginning of the Industrial Revolution (agriculture as the previous heart of the economy, manufacturing as the rising segment, and services as totally independent and unrelated activities in regard with the former two) is a sign for the concentration on remunerated manufacturing work and the negligence of the service activities that complement products and utilization systems instead of belonging to an individual and exclusive group of their own.

In the Service Economy that is less determined by the mere production of goods than by a number of services revolving around them, we need obviously a different approach. Let us first take a look at the status quo of our economy.

At the end of the 19th century about 40 per cent of the working population in Germany (a typical example of an early industrialized country) was active within the primary sector and about 35 per cent in the secondary sector. The importance of the primary sector has been declining steadily until today and now less than 5 per cent of the active population is working in the agricultural sector. The secondary sector saw an increase to 45 per cent in 1950 and has since then declined to less than 35 per cent. The tertiary sector covered less than a third of the economy until the 1950s when it started to rise sharply until reaching more than 60 per cent nowadays.[2]

It is not only this easily detectable shift of working population away from the first two sectors towards the service sector that documents the change of our economy. It is the growing dominance of services also within the other two sectors that highlights the transformation from the age of industrialization towards the modern Service Economy. Intrasectoral services of the secondary sector are estimated to have doubled from less than 15 per cent of the overall economy in 1950 to 30 per cent in 1990, accounting for more than half of all jobs within the industry. If these figures are added to the traditionally estimated proportion of the service sector it will account for at least 80 per cent of the modern economy in terms of job functions. Only a diminishing part of remunerated work, currently less than 20 per cent in "advanced" countries, is still linked to strictly manufacturing activities.

All economic production sectors are dominated by services that increasingly depend on research and development, quality control, maintenance, financing, insuring, publicity and distribution, customer services, recycling etc. in order to render the best possible results. The value of a product or service is no longer strictly related to its production costs but to its performance and losses over a period of time. The "sell and forget" mentality of the era of mass production has withered away. The costs of production are now distributed in time from the very first initiatives at the level of research and development up to the moment of waste disposal and elimination after the utilization of the products or systems.

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[2] W. Gruhler 1990: Dienstleistungsbestimmter Strukurwandel in deutschen Industrieunternehmen, p. 20; and OECD statistics.

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We observe in this process the reappearance of the values of self-production and self-consumption, that were dismissed by economic thinking in the course of the Industrial Revolution. Precisely because material products have less and less value *per se* unless they are adequately utilized, the economic value of utilization and the self-production and self-consumption processes it stimulates require a reintegration of these activities as fully value productive in economic and social terms. Monetarized production is interdependent at a higher degree than ever with non-monetarized production. The amount of work done for auto- or self-production intends to increase particularly in relation to the utilization of complex products, services or systems. As a consequence, these two forms of work became increasingly complementary to the remunerated work in the process of producing "performance value".

This performance value, describing the new productivity of the Service Economy, is measured as the functioning of a product, system or service during a period of time with a minimum of acquisition, maintenance, operating and disposal costs, possible in-built loss prevention and a maximum of result achievement. The cost–benefit ratio is no longer estimated by comparing production costs versus selling price. The set of costs now comprises the design of a product or system, its manufacturing and distribution, its utilization and elimination, including partial or total recycling. Whereas the benefits are measured by performance during the period of utilization.

It has to be understood that service functions have today absorbed the manufacturing process in a similar way as industrialization had started to absorb the agricultural production system 200 years ago. As a direct consequence we have to either adapt our current social and economic theories to the current situation or set up a new general social and economic theory that helps us to better understand reality and provides us with the necessary tools to solve the new problems we are facing. Since the changes are so dramatic, a mere expansion of current ideas recognized as the "prevailing opinion" will not be sufficient. We need a new understanding of how our environment works to further the work in our environment.

2. Determinism, the pricing system and uncertainty

Classical and neoclassical economics are based on a notion of value built into an "equilibrium system". Prices are supposed to represent the equilibrium point between supply and demand at a given point in time.[3] It is here that the notion of performance as measurement of value as well as the increasing importance of service functions in the economic system require a fundamental change in approach. Indeed, the notion of performance cannot be identified with a point in time but must refer to a period of time. Now, the very period during which the system is utilized is inevitably uncertain and can be expressed only as a probability, especially when considering potential external events as well. All future costs, linked to performance, can be understood only in terms of probability. Hence, the basic economic system of the Service Economy is by definition based on uncertainty.[4]

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[3] While classical economics underlined the importance of the supply-side in this equation, the neoclassical school emphasized the priority of demand.

[4] In classical economics, uncertainty is equated with inadequate, insufficient or asymmetric information, as if such information could ever be obtained completely. In the case of the Service Economy and the notion of performance value, uncertainty, and more generally disequilibrium as a condition to the development and dynamic systems, is a key factor.

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Given the functioning of many economic activities in today's world, it is clear that any price set at a given moment merely represents a probability which will be confronted with costs arising in the future during a period of utilization and which cannot be precisely determined (*ex ante*). This has always been the case for the activity of the insurance industry and also explains why this discipline has largely been overlooked by both classical and neoclassical economic theory as taught in universities around the world today.

It is indeed paradoxical that increasingly the price-fixing mechanism of all sorts of activities is beginning to resemble the probabilistic one that faces an insurance manager. This is true for example for a research manager having to choose investment in different projects with varying probabilities of success. This applies to all investments or mechanisms having to do with the leasing of any kind of material and also to any type of production process likely to face unknown future costs related to waste management, pollution and other liabilities. It is another paradox of history that insurance, neglected particularly by economic thinking for the last two centuries, is becoming centre stage in much the same way as the textile industry symbolized practical application of the new methods of industrial production in the 18th century.[5]

The visions of the great economists of the past concerning realities of production and consumption have helped in a powerful way to create the modern world where, despite all the terrible crises and setbacks of the period of the Industrial Revolution, a substantial step forward has been made for the well-being of its inhabitants. The moral ambitions of Adam Smith and his successors have proved illuminating for creating and distributing those basic material products, food, shelter, clothing etc., which with time have revolutionized in the deepest sense human history and led to an impressive increase of life expectancy and general health.

Nevertheless, we are facing a situation where economic reality calls for new concepts, not just a fine-tuning of old ideas. The economists' darling, positivistic prognostic, with its proclamation of a trend, the extrapolation into the future and the ensuing deduction of possible actions, will definitely be unable to meet tomorrow's requirements and cannot fulfil the hopes of many traditional economists who believe in it as a cure-all remedy. We have to adapt to a world where the only certain thing about our future is its uncertainty. We have to dismiss the enchanting concept of determinism to free our minds of the bondage that it creates. It is necessary to expand our horizons, not only in terms of accepting uncertainty as a special case of some selected parts of the economy like the introduction of game theory to explain behavioural patterns but as an inherent element of our lives and all actions. In consequence, we should not aim for overcoming uncertainty as if it was just a one-dimensional problem, hoping for the ultimate formula to emerge that would describe the general equilibrium which would be so easy to manage. Only the fall of the general equilibrium as the reference point for our economic theories will open up the path to new concepts that will provide a better picture of reality and supply new and improved answers to the central questions of economy. In this context we are not only referring to an uncertainty of the first degree where the possible alternatives are known and only the chances of their occurrence are unknown but to uncertainty of the second degree where even the possible events cannot be foreseen.

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[5] All of this points clearly to the fact that the equilibrium system of classical and neoclassical economic theory is based on a deterministic philosophy which the hard sciences abandoned at the beginning of this century. The notion of price uncertainty and disequilibrium is rooted in the philosophy linked to indeterministic systems, which for many decades have indicated the way forward in physics and other hard sciences. This means also that the notion of risk, within an indeterministic framework, is not the eqivalent of threat but of opportinity.

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The historical value of equilibrium theory in economics relates to the fact that one of the essential features of the Industrial Revolution has been the monetarization of the economy as a tool for solving the logistic problems of exploiting ever-higher levels of technology. However, giving the notion of price equilibrium universal significance and a kind of definitive scientific validity is much more a matter of belief or even ideology than part of any truly scientific approach. The notion of equilibrium is not really a concept or explanation but rather a tautology, i.e. something that is right because it is right. It has been given the value or status of an axiom, those basic self-evident truths used by mathematics for developing subsequent logical deductions. Understanding this notion of equilibrium, where supply is equal to demand, is essential, because it explains why economic theory has from the beginning always tended to be one-sided. The notion of economic equilibrium, as the key preoccupation of classical economists in reducing scarcity or of their neoclassical successors in defining the behaviour of consumers, has engendered such attitudes as: "If supply and demand are of necessity equal, once we have clearly understood one part of the equation, we have also, by definition, defined the other side". This is tantamount to a contradiction in terms. This oversimplification has caused classical economists for 150 years to fail to understand that demand had to be expanded to cope with deflationary economic crises. It also has, more recently, prevented neoclassical economists, concerned essentially with demand mechanisms, from getting to grips with the problems of current rigidities of supply, which are at the source of inflation.

The concept of a general equilibrium in an instant in time is also linked to 19th century's quest for certainty. In a positivistic and scientific culture, certainty is equated with scientific evidence: as long as our comprehension of a given situation falls short of total certainty, then, says the ideology, we have not yet achieved the final perfect understanding. But this should be only a matter of time, since sooner or later perfect certainty will be ours and with it the awareness of the ultimate equilibrium. But the theory of a perfect and fundamentally timeless equilibrium is in reality "certain" only because of a pre-established tautology. It has thus become the premise for a system of thought and analysis which views the world as a place of "contingent" imperfection. But imperfections and disequilibria are not "contingent", they are the permanent hallmarks of development and of dynamic reality, in fact of real life.

Over the last couple of decades, the imperfections of general equilibrium have been closely scrutinized by a large number of economists. The notions of incomplete and of asymmetric information have entered the jargon of economic theory and analysis, in recognition of the many obstacles to achieving a perfect equilibrium. But these notions are still used as if a perfect equilibrium could ever be achieved. The utopia of positivist "science in economics" is still there to suggest that we can increase the level of information on market functioning to such a point, that perfect equilibrium will one day be achieved. This reasoning simply shows that the notions of time of the pre-Einstein era, the idea of isolating instant modems of time outside reality, are still with us. Once we enter real time, uncertainty and disequilibrium become the reference criteria of reality. Introducing the notion of real time into the economics of supply and demand (in modern terms, service-based production and consumption) is a radical alternative to the view of the economic process as being based on timeless (instant) equilibrium.

Accepting time duration, i.e. real time, implies that any decision to produce is inevitably taken in a situation of greater or lesser uncertainty as regards the moment in time when the product will be available to the market. In this dynamic view of the economic process, it is recognized that any decision to produce is taken *ex ante* of the traditional moment of economic equilibrium, and that any price definition is always *ex post*.

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The moment in time when the price is fixed in the market is only a part, a sub-system, of a wider economic system. In the succession of decisions over time, from production to distribution, and from the point-of-sale further on to utilization-based activities and the recycling or disposal of waste, the market function of fixing a price is an important event in the process, but only one element in a greater economic system. And in this greater economic system, uncertainty is not an instance of "imperfection" but a given fact, containing incompressible risk components. Any economic activity or endeavour is based on some unknown and uncertain factors or possibilities, simply because its objective lies in the future.

Once we have accepted the dimension of real use, we can attempt to make any future event as probable as possible, but we cannot control it with absolute certainty because we cannot control future time, except by eliminating life. In nature as well as in economic systems, many competitive and often redundant production processes are continuously emerging, only some of which will ever reach the point-of-sale and/or the moment of utilization. Successful modern technologies are only a small part of all technologies, many of which have failed in spite of the money invested in them. One successful product on the market provides a source of compensation in a strategy based on many initiatives, a great number of which will fail. It is at this point that the role of demand, distinct in time from production, acquires a dimension and an importance which makes it an essential part of the economic system, or indeed of any living system.

3. Risk management, vulnerability and volatility

The concept of risk management itself has become common not only for the actors in the industrial fields but also for the financial community. With the advent of more pronounced financial risks that could generate the same disruptive effects for businesses – and in some cases even more severe ones – two distinct branches of risk management exist nowadays: (1) the traditional one linked to industry and related to questions of risks more often than not residing in the physical world, and (2) financial risk management, where issues linked to the monetary sphere are considered. Both are vital for the development of the wealth of nations. It is now increasingly obvious that it is the strategy for managing risks efficiently which is the key issue in order to develop the wealth of nations in all directions and for all sectors of activity. This is the reason why we stimulate the many different activities on national, transnational and global level to understand and manage the different kind of threats to the modern economy and society.

The notion of risk management, as well as the risk management function and professional activity, was first introduced in the United States about 40 years ago. It was the consequence of the growing vulnerability in the performance of modern technologies utilized in the industrial production system.

With time, it became obvious that the success of technology in the modern economic system had increased the necessity to control vulnerabilities for very clear economic reasons. First, it was because specialization had been reducing and at the same time multiplying the classes of risks and their homogeneity. Whereas in the past only a limited number of different risks had to be faced, the new situation confronted the economy with more specific and varied potential hazards due to the new production reality. In addition, technology has become increasingly reliable, with the positive effect that accidents are occurring less and less often. Nevertheless, due to the increasingly complex and interrelated technological systems employed today, in the always more improbable case of a breakdown, the consequences are reaching ever higher levels of gravity in absolute as well as in relative terms.

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These risks have nothing to do with special entrepreneurial, commercial or financial risks, since they depend on the surrounding environment and they occur outside the will of any economic or social actor. They are "pure risks". They simply reflect the vulnerability of a system. But because of their gravity, they have become with time more and more strategically important for the contemporary industrial world even if this type of risk is almost totally dismissed in economic textbooks. The profession of risk management therefore developed not only in the United States but also in the rest of the world as a practical reaction to the changing constraints in the economic system outside a clearly recognized academic analysis.

A second important change occurred in the 1970s when, due to the modification in the way of producing wealth and the new rigidities of supply, the rate of economic growth in the industrialized countries started to decline. The notion of vulnerability therefore extended to the social systems, and the welfare state in general. It is from this analysis that we can open the door to reconsidering adequate social policies in the future understanding of the changing conditions of economic development, for the increase of wealth of nations and for coping with risks and vulnerabilities.

The year 1973 was not only the time of the first oil crisis but also the year when the international monetary authorities decided to abandon the fixed exchange-rate system. At the same time, inflation started soaring after a period of lower, creeping inflation. The mainstream economic community took some time to recognize that inflation was in fact a structural and not simply a cyclical problem. As a consequence, the central banks and the monetary authorities took time to come to the conclusion that it was essential to reduce inflation to a minimum in order to avoid the economy going wildly astray.

But for many years, it was not recognized that something fundamentally new had occurred in the economy and so, for a while, the dominant policy of many governments during the 1970s was to accept and even stimulate deficits and to rely on a future "normal" recovery (a historically rather exceptional 6 per cent GDP growth per year was expected to return for good) to re-establish some sort of equilibrium. This did not happen and all the major turmoils experienced in the industrialized countries during the 1970s and into the 1980s are largely due to this misjudgement. Only in recent years are there signs that the service functions enhanced by a new wave of technological innovations can produce an again unsuspected higher level of resilience and productivity.

In the meantime, the basic constituents of monetary uncertainty like inflation rates, interest rates, exchange rates etc. started to modify the nature of the banking system and to a large extent of the functioning of industrial companies. The latter began to realize that the abrupt modifications in monetary conditions were in many cases having more impact on the profitability of their activities, than their main industrial performance.

Banks and other financial institutions, following in industry's footsteps, were soon to begin talking about risk management, modifying fundamentally the role and conception they had of their own business and becoming involved in managing monetary risks as well as starting to work on their own investment programmes. The development of derivatives and other systems was the consequence of this situation. We are currently in the middle of this other gigantic wave in the global revolution of the economics of uncertainty and risk management, as a key feature of the global Service Economy.

4. The role of "demand"

Any proper analysis of changes in the process by which the wealth of nations is produced in the modern economy, must first have carefully considered what economists call the

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"supply-side", that is the systems whereby goods and services are produced. At first, it might appear that we are advocating a return to the doctrines giving priority to the supply side as proposed by classical economists from Adam Smith to Karl Marx and many others until the beginning of this century. But we should also stress that in the new Service Economy, demand is not simply confined to its traditional function as an indicator of equilibrium. For in the changed circumstances of the Service Economy, systems of production and consumption are extended in a time whose length in each specific case is merely a probabilistic assumption.

In this context, the role of demand is much more important than it was in classical economics. Demand represents a selection mechanism which is not only confined to selecting products and services offered on the market. Even production proposals and ideas for new products are submitted to this selection process and might never reach the market and will never be priced. This is particularly the case with formulating strategies for technological innovation which frequently involve a portfolio of projects each requiring separate investment, only one or two of which have any chance of success and will actually "appear" on the market.

This role of demand, recognized as being essentially a selection system, is also an indication of the change of the philosophical system of reference. As Karl Popper noted, in the Lamarckian system, selection functioned as a kind of normative activity of nature, whereby demand would indicate to production what was to do. This might be partly true for known products, but clearly no consumer ever told Mozart to compose his operas or a computer manufacturer to invent computers. In fact, selection is essential to maintaining the normal working of a system and to checking the efficiency for production in the economic and social sense. It is the "producer" who invents and proposes new or different "products".

Furthermore, in the moment when performance represents the value of production, the consumer becomes much more than a simple "user": he invests time or money, or both, in the utilisation of systems, products and services in order to insure that they work and perform satisfactorily.[6]

Demand is rather a selection mechanism in an inevitably asymmetric system. In the economic and in the biological reality, an enormous number of uncertain acts of production are constantly occurring before being selected by demand. There is an enormous difference between a process whose purpose is equilibrium (supply and demand) and one in which demand has a selection function and not an equilibrium function.[7]

As we have already seen, both classical and neoclassical theories are deterministic theories, based on a Newtonian model implying fixed discoverable laws. The only difference is that the first theory emphasized the supply-side until an excess of supply and lack of demand forced a revolution in thinking. The economic crises of the Industrial Revolution were crises of real deflation, because the need for demand, which could be met by appropriate levels of production, was underestimated.

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[6] The consumer has become prosumer, to use Alvin Toffler's neologism. He describes how in the modern Service Economy (to use our terminology), consumers are ceasing to be passive buyers and are beginning to make their own contribution to the utilization and wealth creation which have very much become a part of production. They often co-produce.

[7] A similar attitude is adopted by Karl Popper in his refutation of induction and his defence of empiricism: "There is no induction: we never argue from facts to theories, unless by way of refutation or 'falsification'. This view of science can be selective, as, for example, with Darwin's theory. By contrast, theories of method which assert that we proceed by induction stressing verification (rather than falsification) are typically Lamarckian: they stress instruction by the environment, rather than selection." See K. Popper, 1977, *Unended Quest*, p. 86.

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All that changed when the devastating effects of the 1929 stock market crash led Keynes to introduce the notion of effective demand, and in so doing to reject the contemporary view that full employment would be maintained or restored after the down-swing of the trade cycle be some self-operating mechanism. Full employment is not simply the normal state of affairs, maintained by the flexibility of wages or interest rates. He argued that the level of employment is itself a variable, determined by certain causal factors. He accepted that, in the short run, the level of employment is determined by the level of output. If the latter is high, the firm will employ more workers than if it is running at a low level. Output depends on effective demand, that is, demand backed by actual expenditure, whether consumption or investment. Keynes therefore turned his attention to what determines the level of consumption and the level of investment in order to understand what determines the level of employment.

The emphasis placed by John Hicks on the notion of demand and especially his introduction of the notion of the subjective theory of value was a valuable counterbalance to the centrality of supply and labour, taken over from the classical economists, in Marx's economic theories and the Marxist economics. It enabled the free-marketeers to defend the notion of a free market by their reliance on a demand-side concept of value.

With the neoclassical economic doctrine the labour theory was laid to rest and the focus was placed on utility. Utility is defined as the quality in commodities that would stimulate individuals to buy them, as Joan Robinson described it. Alfred Marshall maintains that utility is taken to be the correlative to desire or want. The key to economic development then is to encourage growth, and enable individuals to purchase the goods which have "utility" without causing inflation. During the 1970s, productivity growth declined sharply, leaving governments with worsening trade-offs between inflation and unemployment. Attempts to handle these problems along Keynesian lines led to both rising inflation and unemployment. Increasing demand whilst neglecting incentives to produce merely increased stagflation, as the value of incentives was eroded. The goal of neoclassicism or neoclassical supply-side economics then was to increase real output relative to demand, whilst recognizing that demand is based on utility.

As we have seen in the previous chapters, there is nothing new about supply-side economics: indeed, it is what Adam Smith's *Wealth of Nations* is all about. But economic development should no longer be seen as a matter of manipulating supply and demand in order to reach the goal of price equilibrium. Both the Keynesian demand management and the supply-side economics of the neo-classicists fail because they assume that economic theory must conform to a determinist model of scientific laws if it is to be taken seriously. The difference between the two is that classical economics looked to "supply" as the key to interpreting and predicting economic development, whereas the neoclassical economists take the view, that once demand is properly understood, the supply of goods will be there to meet the demand.

An entirely new approach to understanding the complexity of production and the role of labour in production is required since neither supply nor demand taken by themselves can provide sufficient explanations of economic development. In particular, it will mean abandoning the notion that the supply of goods can be increased through the application of technology in such a way that the price can be reduced or held at levels which most people can afford, thereby maintaining a sufficient level of demand to ensure continuing economic development. That view, as we have seen, depends on a misapplication of allegedly scientific principles to economic theory, but also on a failure to appreciate the limits of technology.

If current neoclassical demand-based economics views demand as giving instructions to the economy on how to do things, it provides evidence of the extent to which a fundamentally

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deterministic philosophy still permeates the social sciences, and economics in particular. By contrast, even if a process of selection can provide some hints and information as to its future operation, such hints will in practice always remain a hypothesis which can only be verified empirically later, by the facts. But at the same time, an area of uncertainty will always persist because of the fundamental impossibility of forecasting a fully predictable environment if real time, evolution and dynamics are accepted as the attributes of real life. It must be stressed and repeated again that we are now in a dynamic situation in which a static equilibrium theory of economics cannot help to solve our major problems. Our hypothesis is that of a situation in which economic equilibrium theories are too incomplete to be really efficient. They therefore have to be reconstructed to incorporate more problems and less incomplete hypotheses. This precludes the possibility of simply renaming the older economic thinking that stresses the importance of supply. Time dimension gives a much broader meaning to the production function than it had in classical economics, and it also underlines the essential complementary role of demand. "Disequilibrium" theory requires a proper in-depth understanding of both demand and supply, and at different levels.

Whereas priority in economic theories could in the past swing from supply to demand, considered individually and separately as workable instruments, we now not only need to reassess the importance of the suppy-side, but also the fact that the selection function of demand is an absolute necessity, a complement to the production function. By analogy with the quotation form Karl Popper, we could say that an economic system is obliged to produce on the basis of hypothesis, and even of dreams or of any other process stimulating action and initiative. This is the first essential step. But the demand process must also be as efficient as possible in its selective function and must include criteria on how best to use material and human resources, and how best to reflect societal values.

All this of course does not mean that demand is totally unpredictable when production decisions are taken, but even the best market research studies in the modern economy always involve an incompressible level of approximation. We must accept that no certainty exists, but at the same time any approximation is better than no approximation at all. We have to live with an inevitable degree of uncertainty, which in itself provides the margin for improvement, modification, new ideas and progress.

In spite of appearing difficult at times, the selection function of demand is nonetheless essential. Production without control by selection can proliferate to the point of destroying the entire system. Cancer is a biological form of uncontrolled self-production with inefficient selection. Demand is efficient because of its ability to select. Deterministic philosophy which aspires to perfectly defined demand in advance, to preregulated production, is unnatural, can only be inefficient, and becomes a source of destruction of material and human resources. Deterministic ambition can only survive through its "imperfections". The greater the imperfections, the better it is.

Over time, demand must determine whether in reality available productions are useful. Sometimes, after initial feverish success, as with computer games for example, it may fade out very quickly. In other cases, the fact that this selection mechanism exists at all guarantees a striving for better quality production. Mozart produced his operas among hundreds of other contemporary composers. His work was the essential precondition, but subsequently demand has selected him and every time we listen to his music on the radio or in concert, it continues to select him.

In the new Service Economy, where utilization value implies taking into account real time, demand fulfils an essential role complementary to production. It is no longer a matter of concentrating on either the supply- or the demand-side, as within the framework of general

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equilibrium theory, but on the economy as a whole. Accepting uncertainty means that we have again halved the distance between our economic understanding and reality, just like the arrow in Xenon's paradox.

5. Science and technology in economic history

Technology has been an indicator of economic development as much in the Stone Age or later the Iron Age as it is today in the Information Age. All these epochs are defined by a specific level of technology. But a fundamental change took place at the end of the 19th century: for the first time in history, scientific discoveries began making new forms of technological development possible. This key phenomenon (a marriage between science and technology) was behind a unique growth rate in the industrialized countries for a quarter of a century after World War II.

The marriage, however, not only made technology increasingly dependent on the ability of well educated engineers and specialists to manipulate processes and materials. Because of the link to, and therefore reliance on, basic scientific discoveries, technology was also increasingly dependent on a phenomenon exogenous to the economic process. In other words, raising prices would be of no avail if the technological solution needed was dependent on fundamental scientific knowledge not yet available. This was the case after 1973 when everybody hoped that, with the price of oil soaring, alternatives could be found thanks to technological progress. Ten years later oil prices went down, but only as a result of slow adjustment in the consumption of energy. Meanwhile, an incredible development started elsewhere as scientific knowledge in the field of information storage and distribution achieved an unforeseen level of maturity. In addition, another fundamental change had taken place on the supply or production side of the economy: the growth of services as a paradoxical consequence of the success of manufacturing technology.

There are, of course, always and in all sectors, opportunities for technological improvements but, as they happen in any other human or natural activity, they operate through a process of diminishing returns. Each given set of technologies can be developed up to a maximum boundary, beyond which new inventions (for technology) and new discoveries (for fundamental research) will be needed and developed in a negantropy process. Only when there is a major scientific breakthrough, introducing a new set of technologies thanks to a superior level of knowledge, can a jump in efficiency be achieved that overcomes the law of diminishing returns. We can expect breakthroughs to happen but we do not know their nature or when and where they will take place, and we cannot command them at will when they are of a fundamental nature. As a consequence, economic policymaking should not rely on a given technological dream or ideology to become reality, but stay within the boundaries of the commandable.

In order to appreciate adequately the transition from the Industrial Revolution to the Service Economy, it is essential to consider the role played by science and technology in economic history and theory. The debate on this issue is very often inadequate, confused and sometimes lacking the necessary professional depth.

Technology, techniques and the development of tools have constantly accompanied human history. The Stone Age, the Iron Age and the Industrial Revolution defined a key connotation of human development and such a definition also refers to new levels of technology. It must be clear that technology has never been linked until the end of the 19th century to scientific development. It was the result of human ingenuity, intuition and ability to produce tools to better hunt, domesticate animals, build houses, etc. Even the Industrial

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Revolution, in its first phase, was developed by practical "engineers" able to use steam, without really knowing that water itself is composed of hydrogen and oxygen. The production of iron was the consequence of pragmatic observations which developed through hundreds and thousands of years, without knowing what carbon or iron ore were.

Modern science, on the contrary, is the daughter of the philosophical enquiry to comprehend the structure of the universe and the composition and behaviour of matter and materials. It is essential to understand that only at the end of the 19th century did scientific research make any impact on the production of new tools.[8] We dwell on this because when during the 19th century in most cases (including that of Marx) the notion of science was used, it did not refer to the reality and practice of science. Instead, it pertained to an ideology for which the definition of any activity as scientific was a way, in most cases a dogmatic and ideological way, of attributing to such activity the quality of perfection or certainty and final authority. In a more practical sense, scientific methods referred, and very often still refer, to a job well done, i.e. with maximum precision rendering a desired result. This, however, does not necessarily elevate such processes to the level of science. Analysing the majority of writings on this subject, we gain the impression that it is possible to apply the qualification of "scientific" to any sort of "well done" activity, even, at the extreme, to primitive man cutting stones.[9]

If, on the one hand, scientific advances are motivated by and based on human dreams, and stimulated in some cases by myths, they imply at the same time a constant criticism and identification of limits of any apparently precise definition or certainty. This is the big difference between the philosophical beliefs of our times and those in the 19th century, when, because of deterministic assumptions, science was considered a method of achieving certainty and, as such, in competition with religion.

On the contrary, whereas a religion assumes some truths by definition even if they cannot be proved, science takes as a basis any accepted knowledge or existing scientific theory, in order to find out where and at which point such a theory is inadequate, incomplete and therefore cannot be taken as definitive in time and space. Religion does not spend time in demonstrating the non-existence or insufficiencies of God, whereas science starts from, for instance, the theory of Einstein in order to achieve a higher level of knowledge and tries to discover its limitations and inadequacies. Scientific knowledge therefore has to do with a constant recognition of the limits to certainty. Due to these limits progress is still possible, whereas the philosophies which in past centuries so developed the ideal of progress as a search for certainty in fact destroyed the possibility of progress as a result of their deterministic views. Religious faith has to do with the search for universal truth; scientific faith, if this image can be used in such a case, has to do with uncertainty.

6. Managing the uncertainties of modern science based technology

The predisposition has still remained in some circles to consider science and technology as a kind of magic achievement by the human intellect, conceived in abstract terms, guaranteeing

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[8] This process is very adequately described by David Landes. The analysis of Landes is a very good example of highest academic standard since he belongs to that rarer class of researchers who fit and extend the experience and practical knowledge of many experts who have been involved in manufacturing or industrial professions. See in particular his book *The Unbound Promotheus* (1969). Another key study is D. Landes 1983: *Revolution in Time – Clocks and the Making of the Modern World*, which is an in-depth analysis of the development of the watch industry.

[9] We have dealt with this subject in O. Giarini 1980, *Dialogue on Wealth and Welfare*.

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an unlimited elasticity of supply in the future. Serious analysis is again replaced by the growth of a new myth, understandable in terms of the desire for dreams, but in fact opening the doors in some cases to a kind of modern superstition, that has been the contrary of what science is all about. This tendency has often been countered by an equivalent negative one: modern technology, for other circles, would be at the root of most, if not all, modern "ills".

Both tendencies should be rejected, as technology provides humanity merely with a set of tools that are in themselves neither good nor bad. What is at stake is the responsibility of humankind and the ways in which the tools that technology provides are used. Innovations and discoveries are in any case linked to human nature for better or for worse. Globally speaking, humanity is far better off now than it ever was in the past. The real social issue here is the question of potential reparability.

Most activities, including technological advances, are faced with a phenomenon of diminishing returns. Even when introducing a new technology to overcome the limitations of the existing one, the point of inflection of the efficiency function is merely pushed higher and diminishing returns will set in at a later stage. The chain of subsequent, necessary advancements to overcome the new limitations will inevitably face the same logic. More often than not, this will result in increasingly complex systems that are more difficult to manage, and where any potential failure results in more serious consequences. When analysing and, ultimately, pricing the risks of new technologies, insurance managers are and need to be aware of this phenomenon.

In order to explain the historically rather unique economic growth after World War II (at the average rate of over 6 per cent per year in real terms for a period of 25 years) experienced in the industrialized countries, the understanding of the relations between science and technology is of essential importance. In fact, the marriage between science and technology, which started at the end of the 19th century, took some time to be really consumated, and to be perceived as the fundamental revolution that it really was. It was only at the beginning of the 1930s that research as such, both technological and scientific, became a professional activity in the economy. In other words, specific budgets for research were being allocated to specific goals. World War II accelerated the interpenetration of science and technology so that the production capacities of supply in 1945 were a unique historical event. This fact, largely overlooked by economists – probably because of the lack of other such experiences in the past – explains much of the singular performance of economic growth in the industrializing countries from 1947 to 1973. This reference should be essential when trying to understand what is happening today in the "New Economy".

The advancement of science as a basis for new technologies created the conditions for an economic development that is to this day often neglected or misunderstood. The first issue to be considered is that science, having to do with fundamental knowledge, develops through new discoveries. Such achievements, however, cannot be defined in advance and they mature through a process essentially exogenous to any economic or market stimulus: new findings or new facts are by definition not known in advance and even the path to reaching them is just a matter of hypothesis and often vague probabilities.

If existing knowledge and available technologies can be mobilized to define an achievable project and have it done in a given period of time (the case, for instance, of NASA building a booster rocket to put a man on the moon in the 1960s), the opposite is also clear that whenever new technology depends on discoveries not yet made, the process cannot be considered as a direct consequence of endogenous economic or even cultural forces. This fact and this type of link between science and technology is at the basis of the phenomenon of technology's diminishing returns.

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The notion of diminishing returns is present, under various names and theories, in almost all disciplines, both in the hard sciences (the notion of entropy) and in the social sciences (in economics when it recognizes the diminishing returns of technology of the factors of production). It is clear that the invention, development and production of new tools is a way to fight the phenomenon of diminishing returns. We will illustrate this point with an example.

The normal walking speed of a human being is about 5 km per hour. Short distances, however, can be covered much faster, e.g. 100 meters in perhaps ten seconds. If we want to run 200 instead of 100 meters, it is obvious that the additional 100 meters cannot be run at the same speed as the first 100 meters. This is even more true for longer distances like 500 meters, 5 km or 50 km. The longer the distance to be covered, the longer it takes not only in absolute but also in relative terms. However, by taking a bicycle we can of course make great progress, enhancing our performance. Nevertheless, the phenomenon of diminishing performances – or returns – also applies to bicycle-riding. It may come into play at a later moment but it invariably will do so. Improvements to bicycle technology, like introducing a gear box, lighter frame or thinner tyres, will help to put off the moment when technology finally proves insufficient and inadequate.

A new technology will have to be introduced to overcome the limitations of the existing one. Replacing the bicycle by a car will again improve our performance for a certain time but then we will have to switch to another yet superior system, an aeroplane, and after that maybe a space shuttle. At each level of new and more advanced technologies, we are able to counteract the phenomenon of diminishing returns at a previous level. The higher the level of technology, the more scientific knowledge we have to introduce in order to make the improved performances possible.

There are always and in all sectors opportunities for improvements of the current technology, but they operate through a process of diminishing returns. Whenever a given set of technologies has been exploited to its limits, only the introduction of an entirely new set of technologies can lead to a leap in efficiency that overcomes the diminishing returns. This radical progress, however, is almost always linked to scientific discoveries and inventions that are dependent on an exogenous system.

Therefore, the phenomenon of diminishing returns of technology, which can be observed at various moments the whole development of the Industrial Revolution, has always accompanied us. It facilitates the understanding of this process in the progress of human performance in terms which are realistic instead of being mythical or ideological. And it indicates the way to further developments. We also know that between the moment when a fundamental new scientific discovery is made and its subsequent application in technology, the time needed is rather long and has to be measured in decades rather than years. Some authors provide examples of the quick transposition of new technologies at the industrial level, but they always refer to innovations where no real key fundamental discovery was introduced. What is possible in terms of improvements of existing developments is not to be considered as equivalent to a fundamental discovery which can revolutionize the whole way in which we understand and deal with matters and materials.

Some will remember that the electric car preceded the combustion engine and that for a while both systems where employed next to each other. But efficiency in the manipulation of batteries only improved relatively little and therefore, because of insufficient knowledge of how to control the production and performance of small systems producing/storing energy, priority was given in practice to the combustion engine. The economic choice was conditioned in fact by limits in fundamental knowledge.

It is important to realize the power of technology and at the same time recognize the

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limitations of our ability to command specific predetermined scientific breakthroughs that are necessary to produce specific results. We cannot expect science and technology to come up unfailingly with the solutions to all our problems. Such irrational attitudes have to be combated, there is no modern magic that can be manipulated in any desired way. There will always be an element of uncertainty and challenge involved. This element of uncertainty is the domain of insurance.

7. The Service Economy and the interrelations between technology and economic performance: some concrete cases

In the interrelation between technology and economic performance in the modern world, there is a fundamental phenomenon that in economic terms leads to the Service Economy. This transition can be observed essentially by those having to do with the practice of the industrial production. Here are some examples of a number of practical cases dating back to the late 1960s and at the beginning of the 1970s, and therefore long enough in the past to facilitate the comprehensive (historic) *ex post* analysis.[10]

At the end of the 1960s, it was considered probable that thanks to the new sources of energy produced through nuclear power, the cost of energy itself would drop considerably with respect ot other sources. An energy revolution was expected, similar to the one which happened in the computer industry. A series of techno-economic studies were conducted throughout the world to identify all the chemical processes which could have been replaced by thermo-processes based on nuclear energy. It was at the end of the 1960s that the first problems concerning any real possibility of diminishing the cost of nuclear energy started to appear and destroying therefore the market of research in this area.

During the same period, jumbo jets were offered to the aviation market to carry up to 500 people at a time. The existence of an even bigger aircraft, the military transporter Galaxy, was there to stimulate the idea about a next generation of aeroplanes carrying over 1,000 persons. Until this day, there are no commercial aircrafts of that size. In the chemical industry, research centres were still trying to submit studies and prototypes concerning units of the great chemical intermediaries such as ammonia or ethylene, which were thought to facilitate through a single reactor production of up to 5,000 tons a day. Whereas during the previous 15 years constant improvements had been made, this process then came to a halt.

In all these cases, it appeared that the process of achieving economies of scale in the traditional economic logic had reached its limits. The feasibility of these larger systems was increasingly questioned, taking into account problems of security and the increasing costs of logistics. The organization of making these units work was producing costs higher than the gains obtained by the concentration of production. This means in economic terms that the process of economies of scale was not only achieving a limit but that, introducing the costs linked to logistics (in fact all forms of service activities), the global productivity was diminishing in relative as well as in absolute terms.

The case of liquid fertilizers illustrates this point further. Assuming that they could have been used more easily by farmers, it seemed logical to stimulate the production of liquid fertilizers further. However, such fertilizers could be distributed only in three to six weeks of the year and required injecting machines of a considerable cost, especially taking into account

[10] All these examples refer to studies done by industrial clients in different parts of the world in one of the major world research centres in its laboratory in Geneva.

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that these machines had to remain idle for about 11 months in the year. The notion of the utilization of capital tools in this case was central, together with problems of vulnerability and volatility. In fact, the world fertilizer market at the time already involved the shipmnent of several million tons. The storage costs of the products were and are considerable. It was enough in major consumption areas for there to be a couple of weeks of rains earlier or later than foreseen to provoke considerable pressure on stocks. And even if in some areas highly organized cartels were supposed to manage the whole system, they were not able to control such situations.

For instance, the price of ammonia and related nitrogen fertilizers would multiply or drop by very large margins according to such pressures, originated by a quantity of products which, in terms of the total world market was of the order of less than 1 or 2 per cent at variance with the "normal" situation. Concentration of production and distribution constraints produced much strain on prices which had become, beyond all possibility of control, more and more volatile. Added to this, there was also a storage problem with fertilizers, partly for reasons of humidity.

When in 1973 the oil crisis struck, it happened essentially because of profound changes in production systems and because of the vulnerability of storage and distribution systems. It was first of all the economic system that had become vulnerable and volatile. The capacity of the oil countries to co-ordinate and control the market was secondary and in fact benefited from a situation which was economically and politically exploitable because of the new realities of production and distribution. Here lies the reason why the oil crisis of 1973 became the signal for a general downturn in the overall rate of economic growth (from an average of 6 per cent per year to 2 to 3 per cent for early industrialized countries).

If it had been just an oil problem, this would have justified an increase in the general inflation level of about 1 to 2 per cent only. This was the result of thorough research carried out in the world's major research institutes, taking into consideration the effects of the increase in oil cost in all economic activities. Such studies had already been carried out with input–output models one or two years before the first oil crisis took place. Therefore the oil crisis was just one aspect of something deeper concerning the transformation of the economy. A key aspect of this was that service functions, concerning in particular storage and distribution, utilization costs etc., were in fact key economic factors and the purely manufacturing aspects became a sub-system.

Industrial and manufacturing companies in the world, in the main, understood this situation: they did not need new economic theories, experience was enough. They just had to face obvious problems which needed new solutions that more often than not were found and put into practice. It is at the general macro-economic level that there were obvious difficulties in understanding the fundamental reasons for the new rigidities of supply, for the persistence of inflation and the failure, during the 1970s, of stop-go economic policies.

It might have been different had fundamental new discoveries been made during the 1970s in sectors where they were most needed to reverse trends towards more rigid production systems. But this did not happen and great leaps forward were taken in sectors that were not able in the short run to compensate for the new rigidities. It is here that we find again the logic of the exogeneity of fundamental changes linked to the mechanism of science and technology.

8. Conclusion

The increase of service activities within the production and manufacturing system itself was not and is not necessarily an indicator of increased efficiency of the capacity to grow in

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view of a greater wealth of nations. Economists still need to learn how to augment real productivity of services and even more how to measure them properly. The main problem is the wealth of nations, still calculated today in the terms of the period when the pure manufacturing system was the priority and dominant over every other aspect of economic development.

In the new system, where value is linked to performance, it is imperative to adopt measures to evaluate differently the vulnerabilities of systems, the riskiness of procedures, the impact of failures and disruptions, and the setting up of solutions. They are all part of growth in the wealth of nations and at the same time, understanding the basic realities of the conditions of the production of wealth, promote better economic policies based on the reality of the Service Economy. Our improved knowledge and understanding should open the way for a brighter future. The feelings of impotence or inadequacy of some economic policies is not the consequence of the challenges of reality, but of our capacity to adequately understand them. Insurance experts and risk managers (in both camps, industrial and financial) are a key reference when it comes to integrating true performance costs into the day-to-day running of businesses and governments, indeed, of any institution or activity, as they bridge the gap between the potential and the real, discounting more properly the future as we go along.

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