Evolving Economic Thought to Include the Impact of Technology in Economic Development and Economic Theory Overcoming the Limitation Set by the Analytical Approach

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*[**Abstract**: Today, innovation and technological development are perceived as essential inputs for economic development. Even the non-technical aspects of innovation are recognised likewise. Though earlier economic thinkers perceived the importance of innovation and technology developments, these were marginalised compared to land, labour and capital in the theoretical formulations both by classical and neoclassical economists. Innovation and technology were, at best, recognised contributing exogenously as compared to land and capital which were endogenous to the processes of development. Similarly, the role of entrepreneurs was also sought to be passive in the economic processes. It was not possible to precisely quantify technology, innovation and entrepreneurial contribution in relation to analytical tools based on the principles of mathematics and physics. Thus, these were sought to be excluded by the practitioners of economics, taking on the assumption that economic systems evolved from one equilibrium to another. In the early 20th century, Schumpeter analysed the economic process on a historical and dynamic perspective and credited the entrepreneur as an agent of economic development and for bringing about creative destruction by the deployment of innovation and evolving technology. Such thinking was a paradigm shift in economic theory, giving primacy to technology and innovation towards economic development and exposing the limitations of the analytical framework of neoclassical economics. With creative destruction caused by the application of innovation and technology development, the economy becomes a system whose elements are continually updating themselves and where it is under constant computation. Such a phenomenon is akin to the processes undergone during the evolutionary processes of species under the discipline of biological science which is not developed through mathematical tools. Theoretical formulations of biological science have proven to be sound. Thus, evolving economic thought in economics is required to overcome the limitations set by the analytical approach.]*

Innovation has become a widely used but ill-defined, everyday term in the 21st Century.[1] Initially, innovation was associated mainly with technological aspects and the first application of invention. Nowadays, the importance of non-technological aspects of innovation (e.g., organisational or marketing innovation) are also emphasised and recognised. Initially, the concepts of innovation, invention and

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1 Courvisanos, J. and S. Mackenzie (2014), "Innovation Economics and the Role of the Innovative Entrepreneur in Economic Theory," *Journal of Innovation Economics and Management*, Vol. 2, pp. 41–61. Available at: https://www.cairn.info/revue-journal-of-innovation-economics-2014-2.htm

novelty occasionally appeared in different economic theories. However, the importance of innovation in economy was marginalised. Adherents of classical theory of economics did not regard innovation as an important factor contributing to economic processes in comparison to other factors such as land, capital or labour. Adam Smith did recognise that a growing and deepening division of labour promotes the creation of new inventions, and workers who are able to focus on narrow areas of the production process are more likely to reflect on how to improve their work. Such processes, according to Smith, created avenues for innovation and novelty. In his works, Smith has acknowledged that innovations (mainly machines) facilitated work and made it more efficient as well as allowed the production of goods at lower labour costs, and yet he was critical of banks financing "mad" projects. Even D. Ricardo, while pointing out to the technological progress, emphasised its insignificance for economic growth, holding the view that the machines would cause displacement of labour, a phenomenon which will call for the scaling down of the pace of progress in order to prevent layoffs. French economist Jean-Baptiste Say went further to point out that new machines had to be developed which gave rise to new jobs, often those that never existed. Say, like Smith, also emphasised the benefits of innovation for consumers such as lowering of prices for better quality products.[2] Thomas Malthus asserted that economic and technological growth will bring no benefit to population.[3] Karl Marx was a rare classic theory practitioner who explicitly attempted to bring technology inside the analysis of economic and social evolution. According to him, in the initial stages, the pre-capitalist technological change does not affect the relationship among the productive forces and there is no substitution between capital and labour in the production process because the original appropriation is yet to happen and capital is freely accessible. In the second stage, i.e. the capitalist economy, technological change induces a substitution between capital and labour in the productive processes. A new technology is likely to change the capital-labour ratio in the productive process, usually increasing it. Profit

[2] Lemanowicz, M. (2015), "Innovation in Economic Theory and the Development of Economic Thought," *Oeconomia*, Vol. 14, No. 4, Pp. 61–70.

[3] Palumbo, L. (2010), "Innovation and Economic Thought," Buffalo State College. Available at: http://www.academia.edu/429379/Innovation_and_Economic_Thought

rates will be on the lower side and less efficient firms will be pushed out of the market. The competitive structure of capitalism encourages innovation, because innovative firms enjoy a higher rate of profit due to their monopolistic position. A firm will have to be innovative if it is to remain competitive. The pattern will lead to a further concentration of capital towards a unique giant monopolistic firm. Marx had a fair grasp of the technological unemployment and technology being instrument of pressure on workers, capable to keep the wages lower even during periods of increased economic activity. Overall, Marx's concepts ingrained some elements of endogenous growth theory as well.[4] Generally, however, the practitioners of classical economics tended to excessively focus on physical capital, ignoring the role of intellect and skill in theoretical formulation. The trend continued till the early twentieth century. Even neoclassical theorists continued to neglect technological change and economic development. Similar was the case with early development theories which rejected innovation and technological change. If some such theories sought to include innovation processes, these were treated as exogenous factors such as demographic change and changing preferences. For example, Solow treated technological change as an exogenous factor in his neoclassical theory of growth and implied that growth which could not be explained by the variable endogenous to the model must be a result of exogenous to technical change. He found that increase in labour and capital inputs explain less than half of the economic growth; the residual results from technological progress. Solow continued to maintain that the economy adjusts internally to achieve stable equilibrium growth. Thus, his theory remained rooted in neoclassical view when capital and labour contribute to growth, with technological change as an exogenous factor.

Schumpeter, taking himself away from mathematics-dependent economics, based his analysis on a historical and dynamic perspective, finding the source of economic development in the action of 'entrepreneur' who is responsible for the introduction of innovation in the economic system, and whose actions determine

[4] *Ibid*.

economic development through the process of creative destruction. Innovation creates new value but implies destruction of the pre-existing technology and, maybe, firms.[5] Schumpeter termed innovation as an internal factor because the turning of existing factors of production to new use is purely an economic process and a matter of business behaviour as exhibited by the entrepreneur. The characteristics of an entrepreneur are, by and large, personal and innate. Neoclassical economists have, generally, not taken into account the role of an entrepreneur in their theory. Rather, it has been emphasised that an entrepreneur must play passive in the market as the market sets prices and determines demand. As prices rise, suppliers produce more; as prices fall, they produce less. Perfect market provides a solid foundation for economic predictability which is achieved by eliminating the unpredictable behaviour of entrepreneurial owner-managers who thrive on upsetting market activities by introducing innovative products and services. In the Schumpeterian theory, an entrepreneur has been perceived as playing a determining role. An entrepreneur is, in fact, the agent through which innovations are carried out and actual development takes place. An entrepreneur, seeking profit through innovation, transforms the static situation into a dynamic process of economic development. An entrepreneur is the motive force behind economic change and development and an agent of creative destruction—destroying the existing economic structure and creating new products and production methods. This leads to economic growth and development. Schumpeter thus brought a paradigm shift in economic theory towards evolutionary economics and innovation theory. In the new paradigm there is increasing importance of innovation in growth and development economics and further the static analytical framework of new classical economics is not suitable for analysing the economic role of innovation.[6]

Schumpeterian concept of the role of innovation in economic development though enunciated in 1912, remained on the periphery as it was not based on

[5] *Ibid*.

[6] Eggink, M.E. (2013), "A Review of Theoretical Context of the Role of Innovation in Economic Development," *World Academy of Science, Engineering and Technology, International Science Index 83, International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, Vol. 7, No. 11, pp. 2840–2846.

analytical models—as have been dominating the discipline of economics. Thus, much later when Solow rose to eminence with his theory of economic growth, he postulated that two productive factors are capital and labour, while technology is considered an augmenting factor that may change the shape of production function only. In his framework, the increase in total output may be caused by an increase in the inputs—capital and labour—by a development in technology, also called total factor productivity. While the first two factors are measurable, total factor productivity is computed ex post as the difference between input and output change over time. Technology thus becomes a share of the economic growth that cannot be imputed to growth input and output change over time; Solow called it "Solow residual." Over the years, growth because of the non-economic factor of Solow model and total productivity factor became a black box or some sort of measure of the academic community's ignorance of the causes of economic growth.[7]

"Size of the residual served as a kind of 'wake-up call' to the economics profession because most economists for the previous 200 years had been building models in which economic growth was treated as if it was primarily a matter of adding more inputs into the productive process, especially inputs of capital. The large residual told economists that they had to look elsewhere in order to account for economic growth."[8]

When we wish to explore the role of innovation in economic growth, it is essential to recognise that manifold uncertainties are inherent to the nature of innovation and it would be difficult to forecast how the market will respond to the introduction of new technology, if developed. Initially, in thinking about the impact, even if a new innovation ensues one is more likely to focus on the activities and works of scientists and engineers responsible for creating new technologies in the first place and who, at that stage, may not have envisioned the impact on the creativity of the potential users of new technology. There are several examples

[7] *Op. cit.* 3

[8] Rosenberg, N. (2004), "Innovation and Economic Growth," Organisation for Economic Co-operation and Development (OECD). Available at: https://www.oecd.org/cfe/tourism/34267902.pdf

available where knowledgeable experts went wrong in anticipating the creativity of potential users of new technology such as television, mobile phones, computers and lasers to cite a few.[9] Nevertheless, these technologies changed the course of economic growth and development as there have been entrepreneurs who have ventured into new avenues of technology creation and the momentum generated thus is more than the disruption that Schumpeter envisaged. These novel technologies called for further technologies which, in turn, created demand for more technologies and so on. It follows that a novel technology is not a one-time disruption to the economic equilibrium but the economy is in perpetual state of disruption. Such upheavals induce further uncertainty as businesses and industries do not know what technologies will enter next. Determinate tools for taking decisions are not available in this flux situation. The situation becomes complex and may be beyond analytical control. The economy becomes a system whose elements are constantly updating their behaviour. In a way, the economy is undergoing ongoing computation and evolvement of economy becomes algorithmic. It needs to be expressed as a set of processes triggered by other processes, not in the format of a set of equations as in the science of biology where evolutionary processes are deeply understood on the basis of general propositions that match real world observations and such understandings constitute theories. Biology contains theoretical formulations which are not derived from mathematical equations and it is process based and not quantity based science. Parallelly, a process-based theory in economics can be an alternate to the quantity-based formulation. It would encompass an understanding of the mechanisms that drive the economy without necessarily reducing these to equations. Emphasis under such formulation will be on the driver of change, i.e. on technology. It would become possible to construct computer-based models of key mechanisms that undergo the process of creative formation of new elements from existing elements, new structure from existing structure, and emerging formation proceeding from earlier formation. It may be recalled that no one has succeeded in reducing to an equation-based system—the process by which novel species are created. The evolutionary process is based on

[9] *Ibid*.

mechanisms that work in steps and trigger each other, and continually defines new categories—new species. Evolution's central mechanisms have been deeply understood and form a coherent group of general propositions that match real world observations and these understandings constitute theory in biology. The whole of biological science has developed without mathematical tools. Science of economics—while the economy keeps evolving under the impact of novelty technologies—has to look beyond the physics of goods and services to include processes of change and creation.[10] Problems of allocation and processes of change were equally important to classical economists like Smith, Mill and Marx. These earlier thinkers attempted to make rational science out of allocation while giving their thoughts also to the questions of formulation, governance and history. Economists of Victorian era reduced the problem of allocation to algebra and calculus, holding assumption of rationality and equilibrium. But the problem of formation could not be reduced to limit itself by the strict assumptions of rationality and equilibrium and hence explained by way of mathematical equation and was bypassed by the dominating economists of that era and their succeeding generations. Some economists like Myrdal and Schumpeter continued to study "formation" as their studies were history-specific, case-based and intuitive but not always respected.[11] With the continuous onslaught of technologies, the question of formation of structures and the associated mechanisms has assumed significance in giving reorientation to economic theory to make forecasts about the shape of outcomes.

A convergence of the two streams of economics is on the horizon. Economists who are engaged in developing computer-aided algorithmic models have termed this process "complexity economics" which is towards an integrated approach for studying allocation as well as formation together. This discipline will accord as much to technology as much it does to physical resources like capital, land

[10] Arthur, W.B. (2013), "Complexity Economics: A Different Framework for Economic Thought," SFI Working Paper 2013-04-012. Available at: tuvalu.santafe.edu/~wbarthur/Papers/Comp.Econ.SFI.pdf

[11] Sardana, M.M.K. (2013), "Countries Despite Transformations Taking Place Remain Rooted to their Basic Approach to Economics and Economy," ISID Discussion Note DN2013/03, March.

and labour to explain the emerging paradigms. Science of economics will not limit itself to the tools of mathematics and physics only; it would look beyond the assumptions of equilibrium.