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COMPUTATIONAL INTELLIGENCE EQUIPMENT IMPROVES ECONOMIC SCIENCE USING METHODS AND TOOLS

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Vybavenie výpočtovej inteligencie zlepšuje ekonomickú vedu používaním metód a nástrojov

Abstract: *In a globalised world and in knowledge-based economies, every authentic person needs very specialised skills in economics. A special situation arises for entrepreneurs, because they have to face new demands when doing business. Mainstream economics is untrue in terms of the scientific needs of methodological and ontological approaches, also their fragmentation of the economies in question ignoring their integrity and their implicit order, using only a simple mechanical world view. Primary endosomatic economic knowledge produced in universities and research institutes can be explicated and recorded using ICT and CI for easier distribution and dissemination in a community of broad-based contemporary potential users. However, this is not sufficient for the effective survival of a national economic organism in today's complex world. The most difficult problem is to achieve rapid, high quality and efficient secondary endosomatic knowledge creation by all potential users, i.e. current users and certified experts together. This paper provides a framework for understanding the very important task of creating new economic knowledge for competitive success in a highly challenging environment, while demonstrating, through several examples, possible ways and methods for implementing fast and high quality and efficient devices, tools and methods to achieve these goals. Specifically, the author focuses general attention on devices, tools, and*

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methods that provide advanced computational intelligence results. In this article, we do not explore the creation of new knowledge in the education system, but focus our attention on the contemporary self-creation of new knowledge by authentic persons, aided by new emerging devices and methods primarily using ICT, the Internet, specialized software, simple computational intelligence products and services, and cognitive science tools for these purposes.

Keywords: *Codified knowledge stocks, Computational intelligence, Creative perturbation, Knowledge-based capital, EXCEL and STELLA software, Virtual laboratories*

JEL Classifications: B4, C61, D4, D8, E01, E02, G12, O41

1 Introduction

In an evolving knowledge-based society, knowledge-based capital plays an unprecedented and growing role in the long-term survival of individuals and national societies as a whole. However, these are very vague and confusing formulations of these complex themes. In fact, on the one hand, this important role of knowledge has been present and breathing since the very early stages of human civilization. On the other hand, it is therefore natural to ask the question: "For what reason is this task so often emphasized nowadays?" Answering this question is not easy. In fact, it is clear that knowledge is a prerequisite for the survival of the individual and the family (and, after the Industrial Revolution, of firms, organisations, corporations), the community or society as a whole at every stage of human development. However, the distinctions between the two are becoming increasingly complex as society evolves from lower to higher stages. And this leap from the industrial phase to the level of society's formation and cognition is so colossal that there are no historical precedents for it. We must therefore specify the class of attributes necessary to distinguish one from the other. In the palette of knowledge classification and distinguishing criteria, we must include at least the amount of knowledge used, its quality, nature, level of perfection, types, structure, stability in structure and time of development, methods, approaches, equipment, tools and technologies used to deal with knowledge, etc. The creation of new economic knowledge is crucial for the economic sustainability of society, because economic development is so rapid and turbulent that no citizen or society, or humanity as a whole, can survive with previous knowledge. Not only most advanced economies, but in a historically very short time, the

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entire world economy is transforming from a traditional economy based on resources and hardware to a new economy based on software and information and knowledge. Knowledge in general, and economic knowledge in particular, is now seen as key to determining competitiveness in the 21st century, highlighting the role of information, technology and education in economic performance based on new knowledge. For example, according to the results of expert research from the early decade of the 21st century (OECD 2009a; OECD 2009b; OECD 1996), it is clear that the current position of the national economies of the new Member States in this respect is not satisfactory and is quite far from the needs of the outputs of progress. Therefore, it is very important to work intensively on a task that can change this situation. In this essay, the author focuses his attention on the new opportunities that are emerging in progressive ICT and in the process of developing new devices and tools within Advanced Applied Informatics (AAI) and Computational Intelligence (CI) to realize these requirements. A distinguishing feature of these approaches is their fundamental basis on constructivism in endosomatic knowledge acquisition as opposed to the instructivism that is current in mainstream education. The constructiveness is achieved at a lower level by experimentation in virtual laboratories and at a higher level by the creation of the scientist's, researcher's, student's or any interested person's own virtual laboratories. The author is referring explicitly to endosomatic knowledge new to the subject, not to any other knowledge in exosomatic forms. Making distinction between endosomatic and exosomatic knowledge is very important for understanding the differences between a society's knowledge stock and knowledge capital. We approach the explanation of these subjects neither in the usual nor in the conventional way. In doing so, the author draws on his more than fifty years of experience in social science methodology, based on the decisive use of qualitative simulation methods and/or the intensive use of experiments in virtual laboratories, which he has built up over time on available hardware and software. The culmination of these activities and the achieved know-how is the use of ICT products, the potential of the Internet and the services of computational (or artificial) intelligence and cognitive sciences for the construction and intensive use of virtual laboratories and interactive virtual theatres in economic research, in mainstream systems education and also in private knowledge acquisition in the last 20 ─ 30 years (for example, Andrasik 2009, 2008a, 2008b, 2007, 2004, 1998a, 1998b). In section 2, the author focused on understanding the importance of the distinction between knowledge stocks and knowledge capital for both the individual subject and the society as

a whole. He also emphasized the differences between the process of building a stock of knowledge and the complexities involved in the creation of knowledge capital. Its contribution lies precisely in the discovery and practical validation of the potential of the intended approaches, methods and tools to help overcome the difficulties encountered in this 'transition phase' from knowledge stock to knowledge capital. The third part is devoted to the problems of new knowledge creatively disrupting the existing knowledge capital of the national economy. The fourth part discusses how quality knowledge drifts the national economy into higher orbits of development. The fifth section focuses on advances in new economic knowledge creation facilitated by computational intelligence (CI). Subsection 5.1 shows how theory can be generated with the help of CI, using the example of the duopoly model developed by A. Cournot, but which has been recreated by incorporating the theory of adaptive players. Subsection 5.2 presents the construction of CIs for the behaviour of monopolists in an uncertain market. Subchapter 6 discusses the importance of advanced storytelling with the help of CI on the dissemination of new economic knowledge (building and to other actors using digital storytelling theatre and or stage). Building the stock of knowledge and the painful birth of knowledge capital First, we emphasize that in the current global society and its economy, excellent knowledge embedded in the soma of authentic persons plays an unprecedentedly crucial role. On the one hand, the massive aggregation of the results of basic scientific research achieved after the Second World War creates a suitable nursery of new unconventional technologies supporting the acceleration of the frontal growth of knowledge capital and has triggered profound changes in its quality, structure and ever-increasing efficiency in its practical use for the socio-economic development of nations. On the other hand, the level of use of these ICT, Internet and information technology developments and resources is too low in terms of their real contribution to enhancing the competitiveness of individuals and/or corporations. The impact is most visible in economic processes where (and/or in which) the share of knowledge-intensive jobs is beginning to increase sharply, in parallel with the growing economic weight of the information sector and the increasing share of intangible capital, which is rapidly outweighing tangible capital in the total stock of real capital. These developments are clearly a sign of the steady expansion of jobs in the creation, production, processing, transmission and use of knowledge and information. However, the defining features of these historically unprecedented processes are the massive, widespread use of modern ICT products and technologies,

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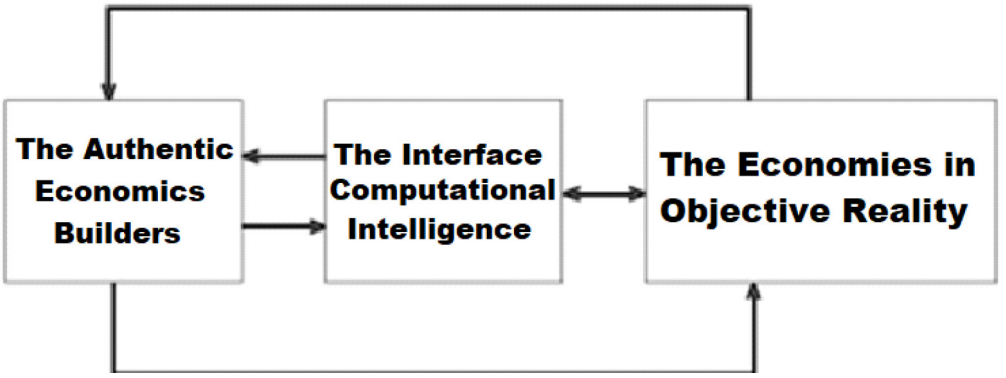
progressive software, computational intelligence products, and in general the results of computer science, information engineering, etc., which is visible on the surface as the massive personal use of mobile phones, laptops, and other special digital devices, and the similar use of ICT products and services in firms, corporations, various types of for-profit/non-profit organizations, in government, and in political and/or civil service administration. In short, *"... the rapid creation of new knowledge and the improvement of access to the knowledge base thus created in all possible ways (education, training, transfer of technological knowledge, dissemination of innovation) are factors enhancing economic efficiency, innovation, quality of goods and services, and equity between individuals, social categories and generations"* (Foray 2004). In order to decide on the volume, quality and effectiveness of the role of knowledge and its impact on socio-economic development, a very challenging measurement task needs to be addressed. The OECD Statistical Office (OECD, 1996) recommends focusing attention on measuring: knowledge in general; knowledge inputs; knowledge stocks and flows; knowledge outputs; knowledge networks; and knowledge and learning. With all these constraints, the creation of new knowledge is naturally associated. It is therefore very difficult to claim a rigorously proven conclusion that new knowledge is the driving force of socio-economic development. But on the surface of the problem, this conclusion is possible and plausible. For example, according to an OECD source (OECD, 1996): *"Knowledge is now seen as a driver of economic growth, leading to a new focus on the role of information, technology and learning in productivity and economic performance."* In the historically new conditions dubbed the global knowledge society, survival is fundamentally linked to the need to understand creative thinking as purposeful. It is therefore not enough to be merely accidental. Indeed, in rapidly evolving circumstances, it is hopeless to wait for things to happen on their own. In an economic context, this means that we need both new and/or innovative content and a deliberately new and/or innovative approach, form and method of thinking. Such thinking is a prerequisite for the emergence of the new knowledge necessary to achieve behaviour in the new permanently changing environment. Based on the preconceived needs, the next step is to acquire the techniques of creative thinking so that everyone can use them purposefully to gain a new perspective on a complex changing socio-economic reality. For a deeper understanding of these challenges, it is crucial to understand that, in the sense of authentic subjects, the process of creating new endosomatic (tacit) knowledge takes place in parallel in different places and in a different subject: - in a place where

a person (group of persons - team) in the role of the main economic researcher creates new knowledge, and, - in a place where a community of authentic persons creates new knowledge after they have been transformed into allies. A simple diagram in Figure 1 is used to illustrate this complex process. Although it is only a simple sketch of this complex process. The aim of the session is to show only in a brief form the complexity of new economic knowledge, skills and the art of using them in the practice of the process of acquisition with the help of ICT, AAI and CI and the status of computational (qualitative) economics.

Figure 1: How CI helps in the process of building economic knowledge: Creating initial tacit economic knowledge and the art of managing it in practice



Source: author

Figure 2: How CI helps in the process of building economic knowledge

Source: author

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Figure 3: Adaptation of Schumpeter's Model I for innovative economic knowledge capital

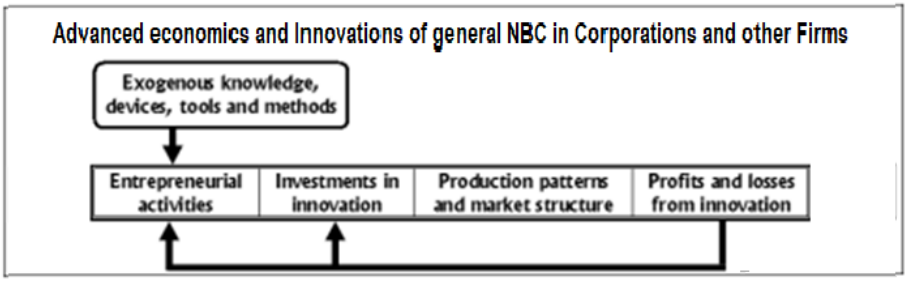

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Figure 4: The living organism of the civic (common) knowledge capital of a national society knowledge capital of innovation

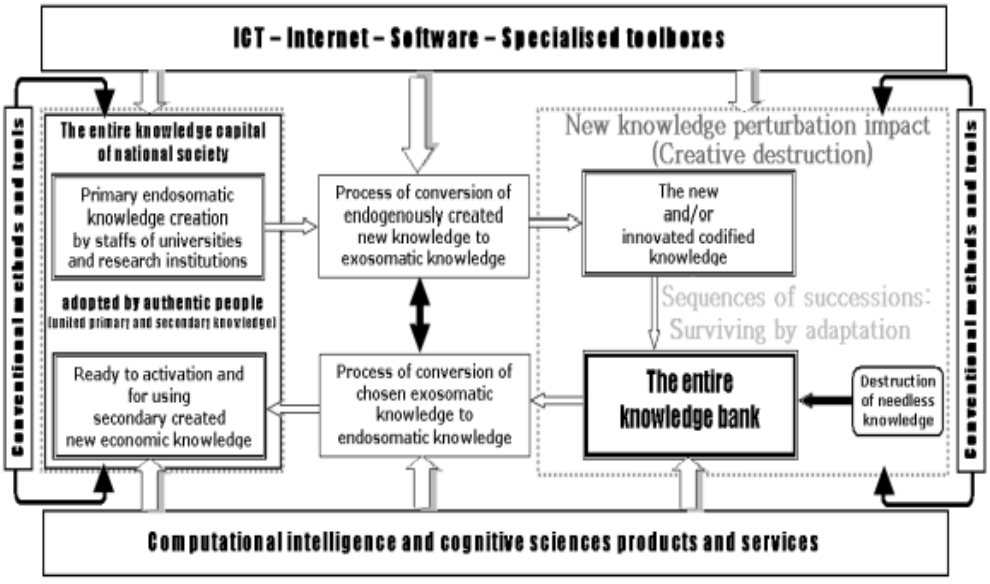

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Figure 5: Knowledge spillover value chain

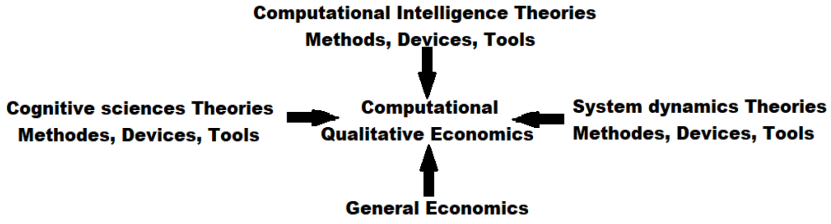

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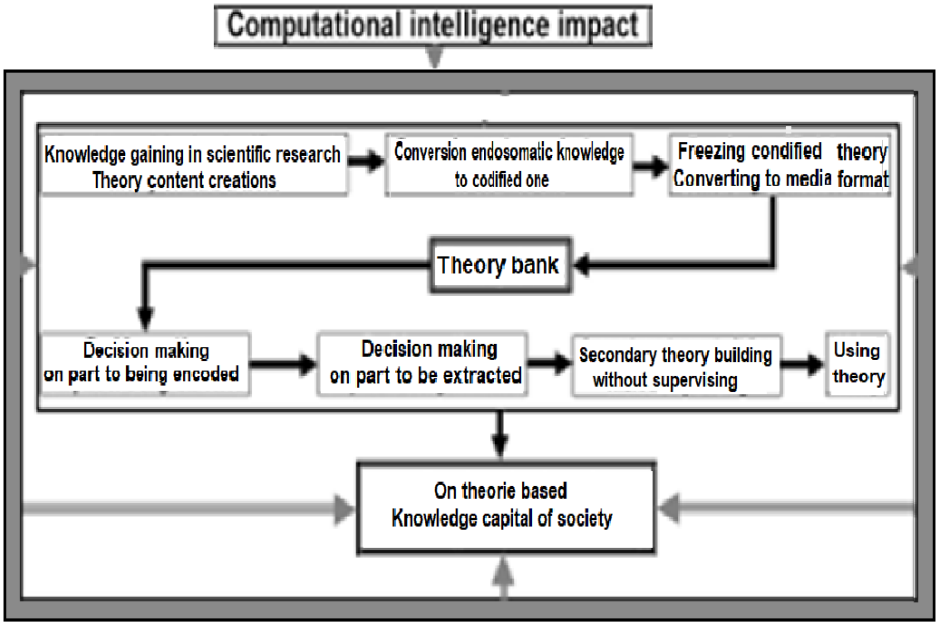
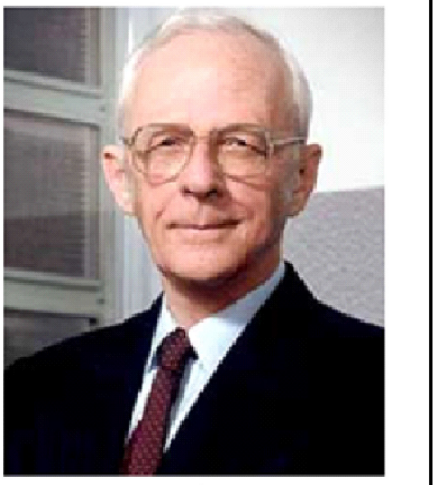
Figure 6: The emergence of computational economics to help deeper understanding of new economies



Source: author

Picture 1: The MIT professor who revolutionized the creation of general knowledge



Jay Wright Forrester
Born: July 14, 1918
Death: November 16, 2016

Computer engineer and systems scientist known as the founder of System Dynamics, which is the simulation of interactions between objects in dynamic systems.

Zdroj: https://www.computerhope.com/people/jay_forrester.htm

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Since the early 1970s, we have been using the excellent theory and methods introduced by the famous MIT professor Jay W. Forrester in scientific work and teaching in universities, see Picture 1.

2 Innovative knowledge through ICT/ICT that supports the integrity of knowledge capital

For a society that has to survive in the complex conditions of the global knowledge economy, it is essential to transform its entire knowledge capital and, in parallel, its economic knowledge box and economic toolbox. It is reasonable to start thinking about the proposed mission by assuming that both economic boxes are structurally stable as one organic whole. That is, previous implemented changes in them do not result in the evaporation of their topological identity. In common parlance, this means something like: "or things remain and continue on their own". However, one might ask the question:

"What are the causes of these changes that lead to the loss of the previous structural stability of knowledge capital?" The answer to this question is not uniform, but as a specific set of questions it may include several. They can be divided into at least two groups: answers related to the content of knowledge and others related to the means and methods needed to achieve it.

It is realistic to assume that creative perturbations, or, to use the term coined by Joseph Schumpeter, "creative destruction" (Carayannis & Ziemnowicz, 2007), play a crucial role in both groups. This statement leads to a very important conclusion: 'It is not enough to create new economic knowledge, but it is necessary to destruct the previous ones'. And this is a very difficult, long-known problem, which was also celebrated by Niccoló Machiavelli in his famous treatise Principe (Machiavelli, 1513).

3 ICT Economic knowledge guides the national economy into a higher orbit of development

The author of this essay agrees that knowledge and ideas are intangible because they "live" in the consciousness of authentic subjects and are therefore difficult to measure by ordinary, convenient routines. Another challenging obstacle to understanding this mystery of hidden knowledge is uncovering the

ability of the authentic subject to successfully use it to achieve expected goals. On the other hand, however, it is intuitively clear that only highly excellent knowledge and a deep understanding of the complex process involved can have a real impact on effective and successful action in a post-industrial society. In this situation, we are forced to make direct use of the assessments existing in published sources of the real impact of new knowledge and skills on socio-economic dynamics.

Intuitively, but especially on the right ends, the author's lifelong experience leads him to the scientific conviction that in the era of global society, endosomatic knowledge, adopted by steadily growing cohorts of humanity, plays a decisive role in development. On the other hand, however, a number of questions need to be introduced into this judgment about this complex nexus. We address only a few of them: -taking a national economy to the next level is not just a matter of a large package of new economic knowledge that is generally (exosomatically) available in common form, but requires a good command of it in the thinking of authentic persons (endosomatic knowledge) and the ability and/or skill to use its power to solve the new problems of the advancing post-industrial economy; such ability will be acquired by persons in - a common educational system dominated by instructional methods; and more effectively and qualitatively through very progressive approaches and methods with the support and promotion of ICT, e-learning, virtual laboratory experiments, the use of well-established (certified) Internet domains, i.e. "knowledge orchards", etc. and in natural cooperation with these three must also be present - more efficient and higher quality production of codified economic knowledge, higher level of endosomatic ideas and mastery of knowledge and the power of its use in the tasks emerging with the progress of the knowledge economy compared to other advanced national economies (ability to compete in the field of new emerging knowledge: to be ready earlier; better and more sustainable). It is known from the economics literature that newly created economic knowledge also has an impact on economic development (and/or growth) through the following five mechanisms: entry; reorganisation; rationalisation; reengineering; exit (exit). For a deeper understanding of the potential impact of newly created economic knowledge (overall tacit and codified) on economic development and on quality of life, it is very important to distinguish between several systemic classifications of its characteristics. In the scientific literature and among members of the professional community, we commonly encounter the consequent admission

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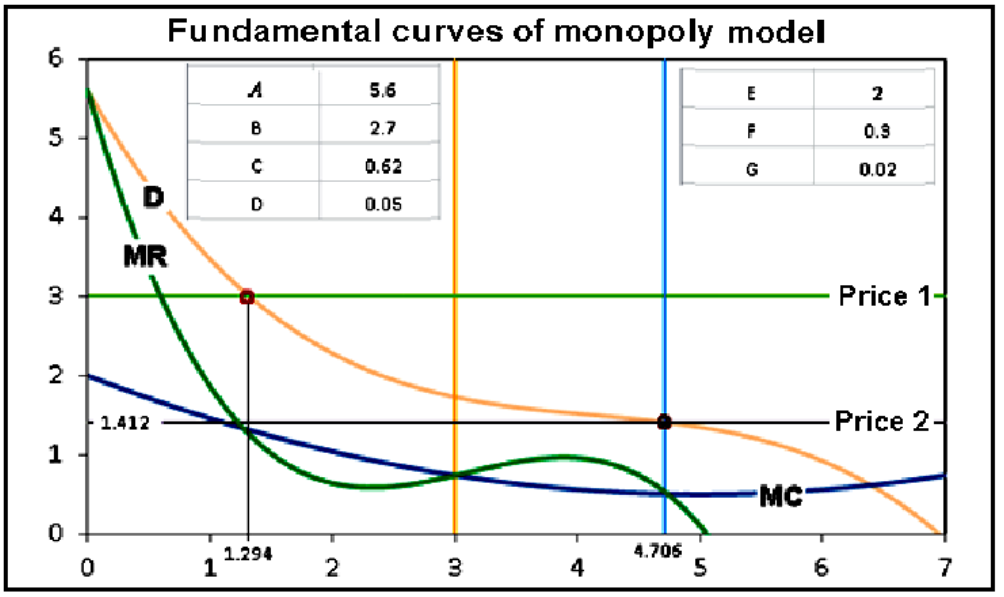
of system-property categorizations of relevance (we deal with them at different levels of aggregation) for new knowledge and ideas, skills the impact of post-industrial development of society (what to do), but for lack of space we have to resign to a deeper analysis of this issue. However, even without it, we must stress the general impact: knowledge capital embodied in some authentic persons - the competences based on them - is a key component of value in knowledge-based firms, concerns, corporations and, synergistically, in the entire national economy.

4 Advances in new economic knowledge brought about by the use of ICT, AC and CI

"Creative thinking is not a talent, it's a skill that can be learned. It empowers people by adding strength to their natural abilities, which improves teamwork, productivity and eventually profits" (quote from a speech by Edward de Bono). A requirement for competence to build new economic knowledge is the ability to use different ways of creative thinking and/or reasoning, imagination, etc. Today, this ability is necessitated by the opportunities to use the wide range of talents provided by ICT, computer science and computer intelligence (CI) products, and new discoveries in cognitive science. The new complex situations that arise in an advancing knowledge-based society force us all to seek effective and amazing methods and technologies for thinking and/or creating and acquiring knowledge, thoughts and ideas that facilitate the transition through the performance of the old industrial era and into the new one. Among others, there are such ways of thinking as lateral, non-linear, parallel and/or tandem, team thinking, etc., but above all thinking based on and armored by ICTs, information technologies, experimentation in virtual laboratories, communication and collaboration with various softbots, think tanks, etc. There are several levels of use of ICT and CI products and services to support and assist in the process of creating new economic knowledge, ranging from the very simple and easy at the lowest level to the complex and sophisticated at a higher level. Examples of lower level software tools include Excel, STELLA, GEMODEL, SIMULINK in MATLAB, WENSIM and others. Slightly more advanced software is SWARM. More advanced software toolboxes are based on artificial neural networks, genetic and evolutionary algorithms and programming, information theory of knowledge systems, classification systems, stochastic graph methods, cellular automata,

percolation theory, Bayesian learning, Petri nets, intelligent information agent theories (and/or agent-based discovery and management theories of information and knowledge on the Internet, in the higher generation of the Web), as well as several stochastic methods. On such foundations, it is possible to generate knowledge in the form of a complex dynamic or evolutionary system. This knowledge is, for example, part of a class of economics called advanced artificial economics and/or advanced computational intelligence economics. In the next part, we generate knowledge about market behavior that is previously unknown to the producer, i.e., uncertain. In this story, we present some results from experimentation in a virtual laboratory created in Excel and in STELLA and iDMC for the behavior of a monopolist in an uncertain market. For the initial demonstration, we use a subsequent simple problem suitable for describing the possible behavior of a monopolist entering a future market with a new ICT product.

Figure 7: The three basic curves created in Excel that were used to create the lab: the monopoly model



Source: author's own calculations

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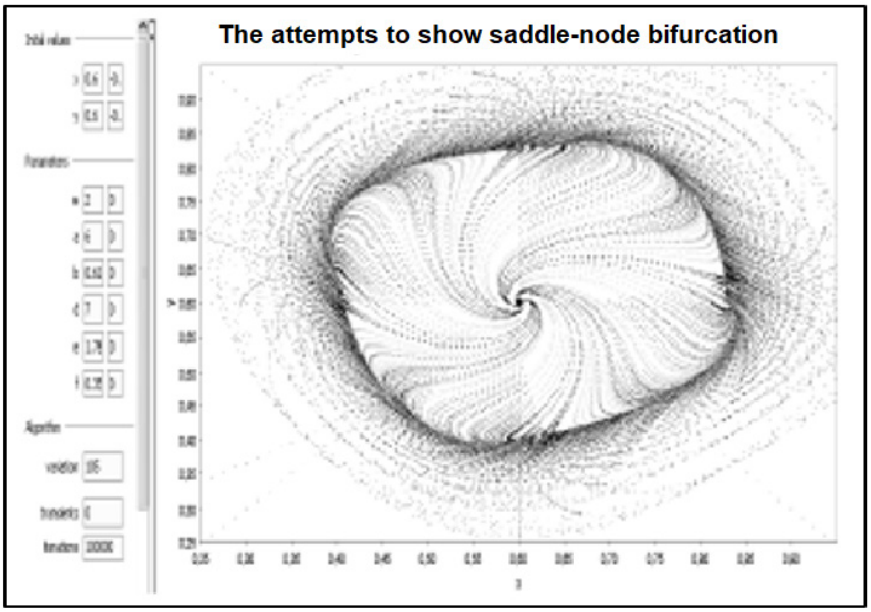
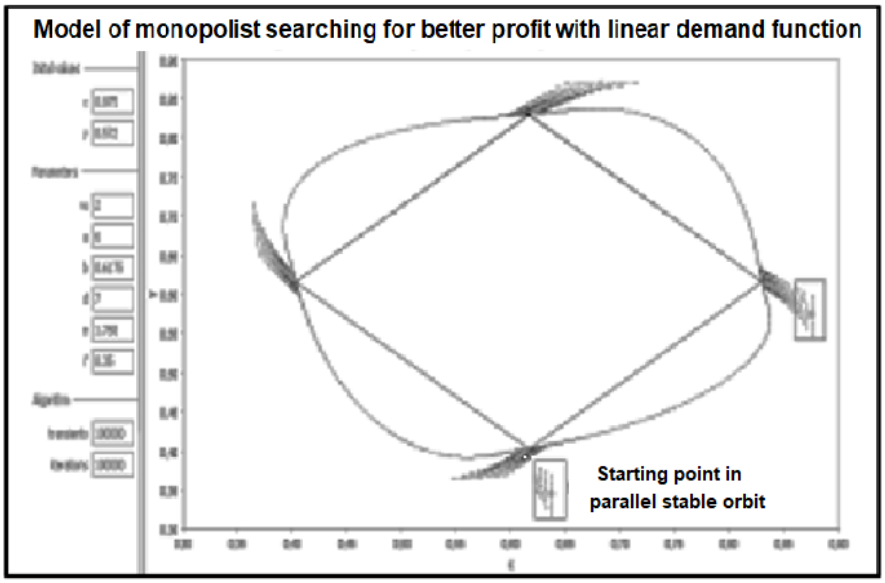
Figure 8: Four trajectories visualising the qualitative nature of four periodic points in STELLA



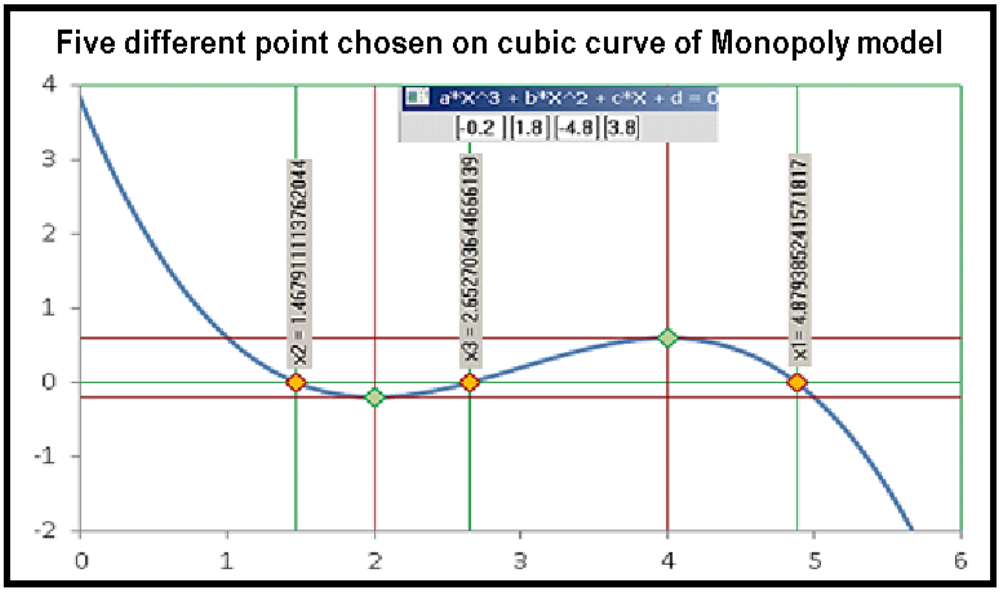
Source: author's own calculations

Figure 9: Bulk changes of the starting point in STELLA



Source: author's own calculations

Figure 10: Monopoly model cubic curve inspiredd by T. Puu´s theory



Source: author's own calculations

Suppose that the monopolist knows only a few points of the linear demand function that he has recently visited in his more or less irregular search for maximum profit. This is an unrealistic assumption, but it is convenient for demonstrating the problems. Then a model with a cubic demand function is also constructed. The slides (Figs. 7 ─ 10) show that it is possible to build virtual laboratories to aid understanding of complex economic processes in a global knowledge society, which could aid new endosomatic economic insights.

5 The importance of advanced information technologies to help disseminate new economic knowledge (building a digital fairy tale theatre and stage)

To increase the efficiency and quality of new knowledge creation, it is essential to make skilled use of the opportunities provided by CI facilities to create endosomatic knowledge in the form of "storytelling". This is sometimes called computer-aided learning (CAL), but a large variety of approaches and methods can be subsumed under this term. The author of this essay, using his

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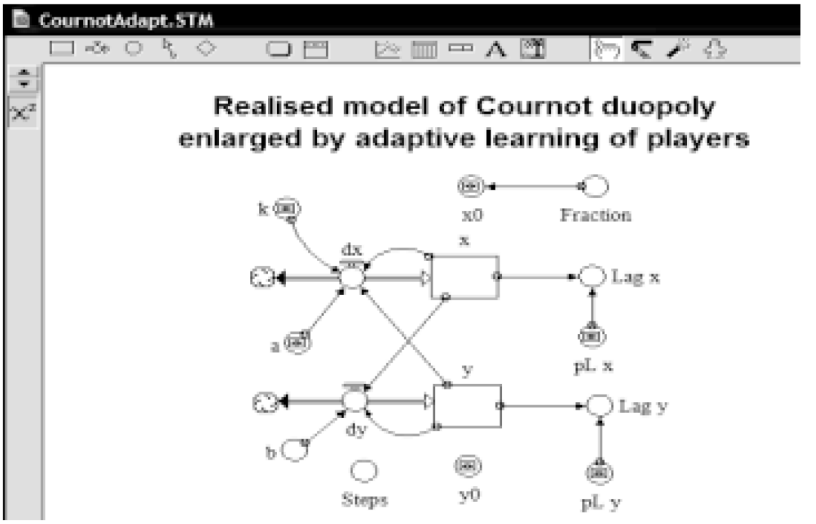
many years of successful experience, declares that the storytelling capability offered by the STELLA software is a powerful means of providing precise control over the model builder's presentation to his audience. It also allows the creation of kiosk-style presentations that progress through the model and explain it piece by piece. Several users of STELLA software who have engaged with it do just that, but storytelling offers so much more. Since the basic premise of system dynamics is that structure and behavior are linked, one of the key ideas of storytelling is to allow the behavioral story to unfold as the structural story unfolds. To create this effect, the program neutralizes structure that is not shown. This is particularly powerful because it allows, for example, the behaviour of different loops in the system to be selectively displayed.

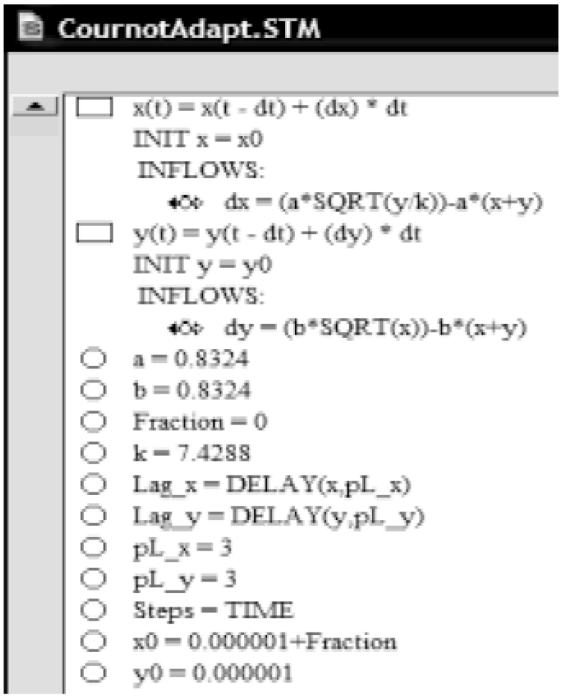
In this section we show just one example linked to the models in Section 5, , that is, we show the process of building stories on duopoly theories and part of the finished storytelling. To build the whole theory for communication in the wider community of scientists, it is important to convert the preliminary theory into a readable one for others of course. Fortunately, CI can effectively assist in such activities. One simple approach to this task is to build stories in programmed form using, for example, STELLA software. Before we start building the STELLA "Story Telling" product for the Duopoly story, we need to build a virtual lab for this case. Just for a visual fingerprint, we will show two snapshots created in this facility when the story is running in manual squeeze mode via the space bar. Snapshots of the stories built in STELLA in some of the steps of "reading" into the stories are shown in the following figures.

Figure 11: Part of the Duopoly model created in STELLA



Source: author's own calculations

Figure 12: Written content of the building blocks of the model (main diagram)



Source: author's own calculations

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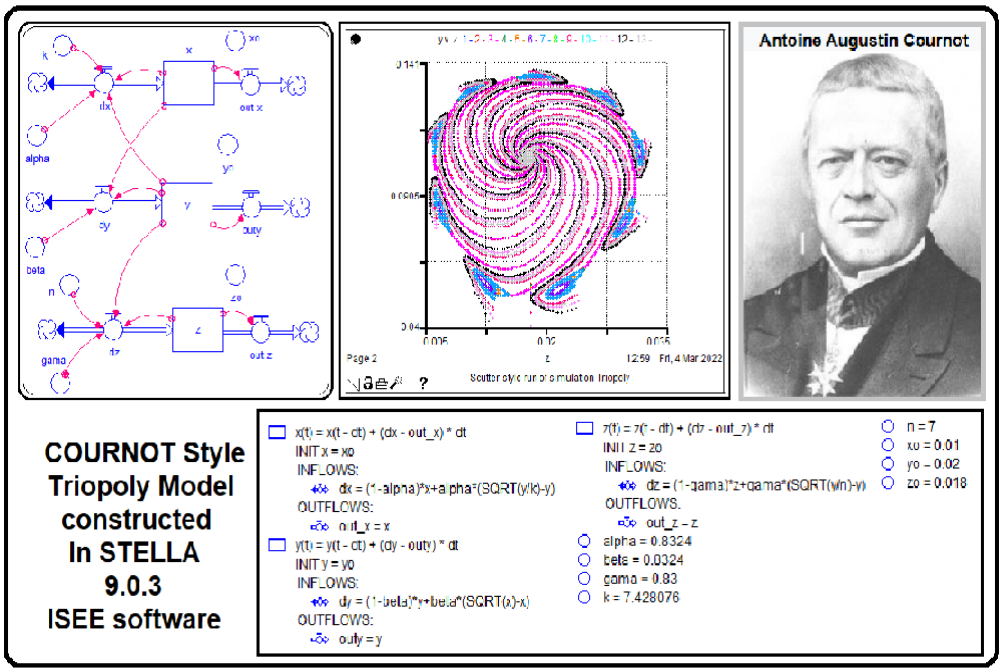
Figure 13: The interactive virtual scene of a several steps of simulation starting point changes in Triopoly model



Source: author

It is now increasingly evident that ICT, artificial and computational intelligence are having a growing impact on a wide class of creative work, the intellectual realm of business, etc. On these bases, significant shifts in the structure of the intellectual resources of economies are being realised. The main change is the move towards higher levels of creativity in knowledge capital. These are the reasons why we need to focus scientific and business awareness on the broad area of the impact of ICT, artificial intelligence and information technology on the structural changes in the intellectual capital of economies brought about by rising creativity. This is the content of the next part of our essay.

6 Growing creativity, fuelled by ICT, R&D and AI and innovation, is leading to structural changes in knowledge capital in advanced economies in the 21st century

Based on Schumpeter's perspective, it is widely acknowledged that the application of innovation and advanced technologies can be an important driver of current structural change. The current vintage of robot + softbot and artificial intelligence (R+S&AI) technologies are primarily manufacturing devices that increase labor productivity and reduce the demand for labor-intensive, routine work in a predictable environment. As such, we quote sentence by sentence what Vermeulen and co-authors (2020) write in [p. 60].

"The future of creative work may mean an absolute decline in demand for such routinized work, or rather for work in general, and a relative increase in demand for more knowledge- or intellectually-intensive non-routinized work and low-skilled work that is difficult to automate (Goos et al., 2014). However, there is some concern that the impact of research and innovation on employment differs from that of previous waves of technological change. Particularly in terms of structural change, it remains to be seen whether the emergence of new industries is as massive as the radical expansion of manufactured products and services in the past. Here, the effects of the introduction of research and innovation technologies on employment and how the labour saving effects are offset by an increase in labour demand are being examined more closely." In addition, they write that the introduction of R&AI will affect the tasks performed, the skills required, the demand for jobs, and hence the (inequality) in wages achieved, (un)employment, education required and job opportunities for people. An important proposition about the impact of the introduction of R&AI is that although productivity gains reduce the demand for (in particular types of) labour, this can be offset by the creation of new tasks performed, skills required and jobs in demand A very important novel proposition is also that new industries are born under the forcing of ICT, AI, CI, Softbots and Myslits. Vermeulen and co-authors (2020) also write in [p. 66] that *"In addition to developments within and between existing sectors, new sectors are emerging, many of which cannot yet even be properly named or delineated. Innovations of various kinds may eventually result in new industrial and service activities that are so different that they emerge as new sectors that create jobs for (some) unemployed people. What these new sectors provide in terms of products and services can often be difficult to imagine in advance. In the 1950s, for example,*

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few foresaw that information and communication technologies would give rise to many industries that have grown to such a size that they would be applied in the number and breadth of ways that they have. These new products, new services and new industries are a fundamental resource." The future of creative labour economic growth has been written about previously by, for example (Pasinetti, 1981; Schumpeter, 1942). Importantly for this class of economic thinking, the findings of Vermeulen and co-authors (2020) provide support for the claim that creative industries are key to future economies. Initially, these new industries are often characterized by labor intensiveness. This restitution effect may be necessary to achieve balanced growth. However, there may be a significant mismatch between the skills of the unemployed and the skills needed for the new occupations. Indeed, the unemployed may perform routine tasks in a predictable environment, while emerging occupations may involve high-skill, knowledge-rich jobs.

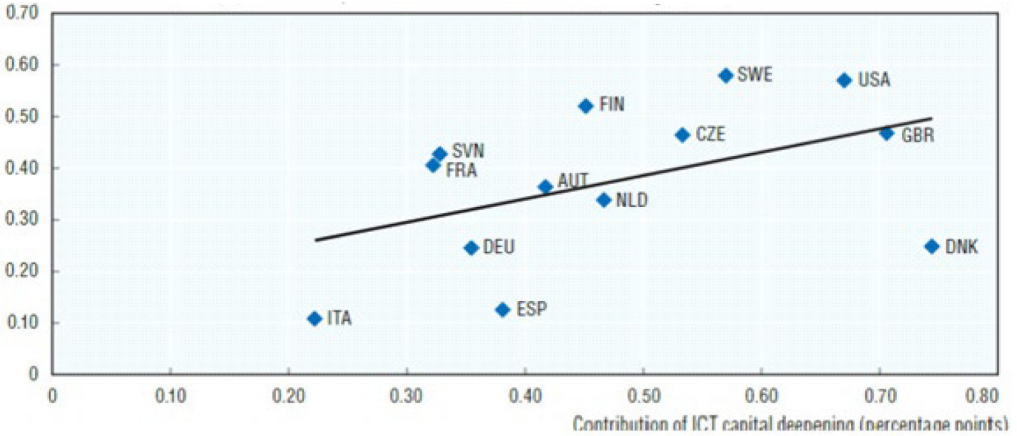
Table 1: This table shows the level of knowledge-based capital in the V4 countries

	Knowledge & Technological Outputs	Creative Outputs
Slovakia	32,3	38,6
Czech republik	42,8	46,2
Poland	27,2	36,3
Hungary	44,4	36,5

Source: based on Global Innovation Index 2011-2017 http://english.gov.en/r/Pub/GOV/ReceivedContent/Other/2016-08-12/GII-2007-Report.pdf

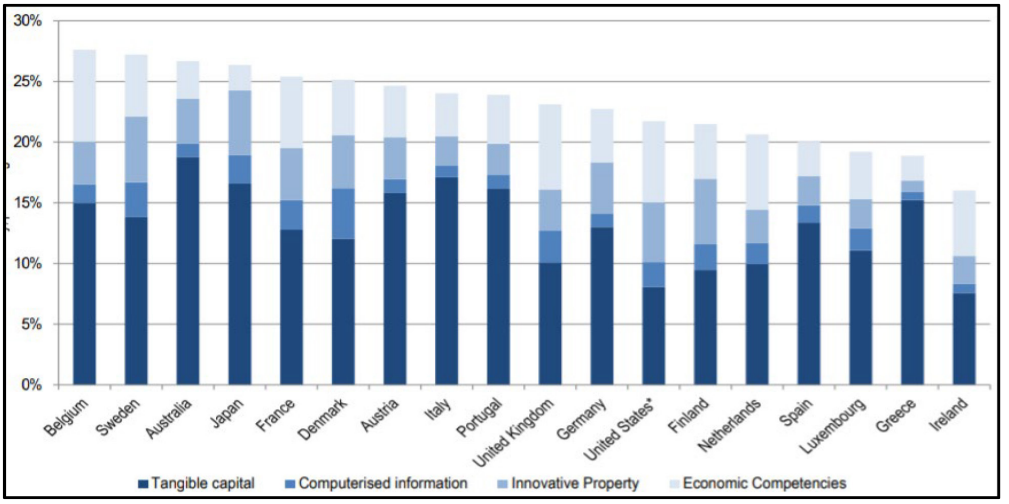
Figure 14 shows the contribution of KBC deepening (less software) in the 12 EU countries and the US (in percentage points), this figure from Corrado, et al. (2017) and the next part of it also helps us to understand knowledge spillovers, ICT and productivity growth, i.e. from the SYNTHESIS REPORT entitled: New Sources of Growth: Knowledge-Based Capital, Key Analyses and, Policy Conclusions.

Figure 14: ICT investment and KBC are positively correlated, 1996-2007



Source: Corrado et al. (2017)

Figure 15: Business investment in KBC and tangible capital, 2010 (% of value added)



Source: https://www.oecd.org/sti/inno/knowledge-based-capital-synthesis.pdf, page 15

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7 Conclusions

In this essay, the author seeks to introduce the advanced methods, devices and tools provided and operated by contemporary ICT, artificial intelligence and information technology. Innovative socio-economic insights can be realized through creative modeling and simulation in appropriate software. For this purpose, the author has used simple and easy to use STELLA and Excel computing/software environment. In this way, we contribute to the pursuit of associative economic reasoning. Such an endeavor is similar to methods of building innovative technological knowledge and creative skills, which are perhaps essential and highly significant as such among the advanced foundations of socio-economic development in the global economy.

Moreover, such an innovative understanding can be seen as a key enabler of globalisation: it is the interface of extraordinary technological innovations, combined with their global reach, that gives today's changes their particular complexity and, with them, their holistic character. Advances in life sciences, digital technologies and the like have opened up vast new possibilities for production and exchange. New devices such as ICTs, CI and the Internet have made it possible to access information and resources around the world - and to coordinate activities in real time - as a potential. In general, the economy in the age of the knowledge society differs from the traditional economy in several aspects, but we focus on the following key aspects:

– The importance and outcome of place is gradually diminishing. The world is getting smaller and smaller step by step. Using appropriate technologies and methods, virtual markets and virtual organizations can be created that offer the benefits of speed and vibrancy, continuous operation and global reach;

– Economics is not about scarcity, but about abundance. Unlike most resources, which are depleted when they are used up, information and knowledge can be shared and actually grow through application; laws, barriers and taxes are difficult to apply solely at the national level. Knowledge and information "leak" where demand is highest and barriers lowest; Knowledge-enhanced products or services may have price premiums over comparable products with low embedded knowledge or knowledge intensity; Price and value are highly context dependent. Thus, the same information or knowledge may have significantly

different value to different people at different times;

– Knowledge that is deeply embedded in people's selves, embedded in systems or processes, has a higher intrinsic value than when it merely levitates above people's consciousness;

– Knowledge capital embodied in the soma of authentic persons - based on these competencies - is a key component of value in knowledge-based firms, concerns, corporations and synergistically in the entire national economy.

We can emphasize the fact that the frontiers of physical science and technology have focused attention in the last two centuries. In the last and this century lies the frontier of thinking more simply about the behaviour of social and economic organisms, and the approaches, devices and tools of ICT, AI and CI have successfully served these purposes. Our long-term practical and theoretical handling of these technologies has been very successful and this is the reason for recommending their use in economic research, teaching and education. In section 6 of our essay entitled: Growing creativity using ICT, R&D and AI and CI leads to structural changes in knowledge capital in advanced economies in the year 21. Century, we used facts about knowledge creation and about knowledge capital existing in objective reality from the Internet. For example, the graph in Figure 14 visualizes the contribution of deepening KBC (less software) in 12 EU countries and the US (in percentage points). This and similar graphical information helps us understand knowledge spillovers, ICT and productivity growth based on them.

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