INNOVATION AS A FACTOR FOR HUMAN CAPITAL ACCUMULATION

INOVACIJE KAO FAKTOR AKUMULACIJE LJUDSKOG KAPITALA

MSc, Krustina Atanassova, PhD Student[9]

Abstract: *There is already a good amount of evidence regarding the influence human capital exerts on innovation activities. However, a reverse relation can also turn out to be true. Here are addressed the links between the percentage of innovative firms in a set of countries and patents registered in the EPO on one side and the values of the so-called human development index (HDI) and the number of R&D personnel in all sectors of the economy. Significant evidence is present regarding the explanatory role of the patent dynamics for both used measures. Less support is founded for the hypothesis relating the R&D role when the activities of innovative companies are being under consideration in the model.*

Key words: *human capital, innovation*

Sadržaj: *Već postoji dovoljno dokaza o uticaju ljudskog kapitala na inovativne aktivnosti. Međutim, obrnuti odnos može da se ispostavi takođe kao tačan. Ovo se posebno odnosi na vezu između procenta inovativnih firmi u određenom broju zemalja i registrovanih patenata, na jednoj strani i vrednosti tzv. indeksa ljudskog razvoja (HDI) i broja R&D osoblja u svim sektorima ekonomije. Značajan dokaz ogleda se u vezi sa objašnjenjem uloge dinamike patenata za obe mere koje se koriste. Manja podrška je potrebna za hipotezu koja se odnosi na R&D ulogu kada se aktivnosti inovativnih kompanija razmatraju u modelu.*

Ključne reči: *ljudski kapital, inovacije*

1. INTRODUCTION

One can hardly doubt that innovation is a major force of economic growth. Moreover, there are significant spillovers between countries, firms and industries. Turning back to the past century, Abramovitz [1] characterizes fundamentally two ways of increasing the output of the economy. Either the number of inputs going into the productive process can be increased or new processes can be designed in order more output to be obtained using the same number of inputs. Obviously, it is a matter of interest to find out which one would lead to better results and how much better they will be. This brought to measurement of the growth in the output of the American economy between 1870 and 1950, and then the growth in inputs (of capital and labor) over the same period of time. After that some assumptions about how much a growth in a unit of labor and how much a growth in a unit of capital should add to the output of the economy were presented. And it turned out that the measured growth of inputs (i.e., in capital and labor) between 1870 and 1950 could only account for about 15% of the actual growth in the output of the economy. In a statistical sense, then, there was an unexplained residual of no less than 85%.

[9] Technical University of Sofia, 8 St.Kliment Ohridski Boulevard, Sofia 1756

It is a broadly diffused idea among economists and policy makers that the innovative capacity and the ability to imitate new technologies adopted across regions are key factors in determining the rate of growth of an economic system [2] – [5]. Moreover, problems related to the production and the diffusion of innovations, make technology policy becoming one of the priorities in their agenda [6].

Going as back as to Joseph Schumpeter [7], technological change is one of the major determinants of industrial change and consists of the introduction of new products (product innovation), production processes (process innovation) and management methods (organizational innovation) in an economic system. There has been a lot of research on the topic what factors actually serve as pre-determinants of the innovation activity and obviously, the human capital is if not the most essential at least a core one. Following the above logic, one is easily tempted to believe that without human capita innovation cannot take place or in case of such a chance, it would be quite a low one. Consequently, another question comes to mind, i.e. what presumes human capital accumulation then? This paper is devoted to the research and development of another non-conventional relationship, namely the impact that innovation exercises on human capital accumulation.

The remaining studies are combined in four major sections: Section 2 throws a broad look on the subject; Section 3 sheds light on what actually stands behind the terms "innovation" and "human capital"; Section 4 addresses the question regarding the alternative to use the number of patents and the percentage of innovative firms as determinants of the increase of R&D personnel and rise in the human development index; Section 5 provides the reader with the empirical evidence comprised and analyzed and Section 6 concludes the paper.

2. LITERATURE REVIEW

The application of capital concept on human is not recent. The point that humans and their qualifications might be a part of capital has proponents among economists, since the birth of science of economics. W.Petty, W.Farr, A.Smith, J.B.Say, N.Senior, F.List, J.S.Mill, Marshall, V.Thunen, W.Roscher, W.Bagehot, E.Engel, H.Sidgwick, L.Walras and I.Fisher are some of the most prominent of these economists. The Classical English School has accepted that skills gained by humans are some form of capital while some economists assert that the human himself is capital. Walras and Fischer defended the latter. The second view has been accepted by economists who are involved with income distribution and production theory.

Human Capital Theory (HCT), together with homogeneous work force assumption of neo classic theory has been replaced by heterogeneity of labor. Differences in levels of education and skills gained by persons require that they receive different wages. The consequence of this is a shift from a functional distribution income to an individual distribution of income [8].

The first views on this subject are based on the studies of Smith and Mill. According to the compensation view of Smith, labor mobility gives rise to wage differences that equalize net advantage and disadvantage of the work. In the non-competing group's doctrine of Mill and Cairnes, lack of sufficient labor mobility causes real wage differences and this brings about legal, cultural and social hierarchy [9]. Research on labor market has proceeded on these two principles. Smith's compensating principle is applied on wage differentials caused by vocational education. Smith argues that a person receiving education was in loss because of not working and such qualified people were to be paid more wages and only then they could

fulfill their costs of education and receive gains. This view has constituted the basis of human capital analysis.

Successively the theory has been improved by Becker, Mincer, Schultz [10] – [12]. Human capital has been criticized from different points of view in time. One of the criticisms is that the theory is difficult to be tested, the quality of education cannot be properly considered and those who take investment decisions cannot calculate its possible rates of return. Another point being criticized is the problem of skills. One can have a good amount of skills and abilities without ever entering a university. Finally, another criticism of the theory is the dual job market in the context that education will not be sufficient in eliminating income inequality.

What also needs to be taken under serious consideration is the way the human capital has been measured within the time periods mentioned. For instance, Mankiw, Romer and Weil use primary and secondary school education as a proxy to measure it [13]. As logical as it may seem this is hardly to be interpreted as a basic measurement. Taking the human capital investment in the form of education does not take into account investment in other social services such as health services, insurance, etc. Neither the technological and social transfer of know how is estimated at all. Consequently, this type of measure may not be exactly precise.

3. INNOVATION AND HUMAN CAPITAL

Innovation in its broader perspective can be generally classified as the attempt to try out new or improved products, processes or ways to do things. It is an aspect of most if not all economic activities. It includes not only technologically new products and processes but also improvements in areas such as logistics, distribution and marketing.

Today, innovation is facing new challenges. Its own dynamism has produced a world that requires in many ways a rethinking of innovation itself. In the corporate sector, the determinants of innovation performance have changed in a globalised knowledge-based economy, partly as a result of recent developments in information and communication technologies. Strategies like market capitalization, mergers and acquisitions and just-in-time delivery, have to be revised in the light of the Internet, online shopping and digital TV. Companies are hungry for new ideas about new ideas [14].

Generally innovation can take many forms. It can be a process, a product, a service or anything else that serves for a better performance and provides a greater value for the society. The innovation can originate from anyone who is able to “think out of the box”, who possesses a mindset that is capable of looking outside the already perceived boundaries and generation and implementation of new ideas into reality. And actually, going back to Abramovitz innovation may not and should not be perceived as just improvement. Improvement is a sort of refinement of existing methods to get more output from the same input while innovation is capable of breaking new ground, delivering new outputs out of less or different inputs.

Innovation can originate anywhere. Increased education and economic growth have improved the capacity of developing countries to offer new products and services. Modern communications and transportation technologies allow these countries to share

advances with consumer across the globe. So, inevitably while speaking about innovation turning to human capital is an essential part. Quite great amounts of literature exists on the subject of how human capital accumulation influences innovation.

Success depends mainly on people with higher level competences. In the economic perspective, the capital refers to factors of production used to create goods or services. The human is the subject that takes charge of all economic activities such as production, consumption, and transaction. Thus, it can be recognized that human capital means one of production elements which can generate added-values through inputting it. Generally, two types of human capital are recognized. The first is to utilize „human as labor force" related to economic added-value that is generated by the input of labor force as other production factors such as financial capital, land, machinery, and labor hours. The other is that the human capital can be viewed as the target of investment through education and training. Consequently, human capital expansively includes the meaning of "human as creator" who frames knowledge, skills, competency, and experience originated by continuously connecting between "self" and "environment".

Krustina Atanassova *is an industrial engineer with strong passion for entrepreneurship. She graduated the Technical University of Sofia with honors and currently is pursuing PhD degree there. She is currently researching optimal ways to integrate the SCRUM Agile methodology in the management of innovative projects between the scientific institutions and the business in order to facilitate and improve the collaboration between the latter two.*
She has been active in several student organizations – Business Booster Sofia, ESTIEM and ABLE. Business Booster Sofia is a Center for Entrepreneurship and Innovations aiming to establish a favorable for entrepreneurship environment for engineering students from different specialties. ESTIEM combines technological understanding with management skills. Its network consists of 79 Local Groups in 31 countries, reaching out to 60 000 students. In 2012 with her team won the largest pan-European case study competition for Industrial Engineering and Management students – TIMES, organized by ESTIEM. She is also an executive member of ABLE - an NGO aiming to develop an active civil society, inspire leadership and spread the entrepreneurial culture in Bulgaria.
In 2011 she won the EMPOWER Young Leadership Development Internship Program. In 2013 she was selected among 400+ applicants to participate in five weeks of intensive academic immersion at the American number one for entrepreneurship - Babson College (Boston and San Francisco), and the Institute of International Education in New York.
She has worked for Lufthansa Technik Sofia as a production planning, forecasting and development engineer for 3 years. She has been on-site trainer for several production companies in Sofia. Currently, she is working as an IT project manager in CSC Bulgaria.

In the 1950's, some economists discovered that the investment of human capital was the primary element to raise individuals" wages compared to other components such as land, financial capital, and labor force [15]. Throughout the investment of human capital, an

individual's acquired knowledge and skills can easily transfer certain goods and services with practical values [16]. Furthermore, it is acceptable that the conceptual foundation of one's human capital is based on "something like knowledge and skills" acquired by an individual's learning activities. So, to sum up human capital equals knowledge as a broader meaning.

4. MEASUREMENTS

With perceiving about the importance of human capital, many nations have tried to effectively and efficiently measure their human capital to understand their current status. Thereafter, human capital measurement is an important source in terms of suggesting and implementing policies regarding human resources. First, Wolf [17] suggests that some of the indicators can be actually considered as incomplete indicator to measure the human capital (e.g. proxies such as income and productivity). Second, it is difficult that human capital itself independently contributes to individual development and national economic growth. According to Ashton & Green [18] it is necessary that the link between human capital and economic performance should be considered within a social and political context to precisely measure the human capital. Financial, human and social capital positively influence "something like individual health" [19] – [22]. Nowadays, it is safe to say that human capital can be interpreted as a synonym of knowledge embedded in all levels such as an individual, an organizations and/or a nation.

For the purpose of this paper I use two types of measurements for human capital – number of R&D workers and Human Development Index (HDI). I chose the first one as having been unsatisfied with the usage of just an education factor. Actually, the education factor is included in the R&D personnel as otherwise they would not be able to occupy this position. Many authors recognize the R&D more as a measurement of innovation itself. However, one can doubt that this is the case. Innovation may be a result of such activities but not necessarily of them only.

Moreover, innovation may occur without any R&D at all. What in fact the R&D delivers is a greater portion of knowledge in a given field or an alternative way of utilizing knowledge, but it is always related to knowledge.

On the other hand, the human development index has been reported by the United Nations Development Program (UNDP). The structure of the index is constituted to health, knowledge, and standard living with many sub-variables such as life expectancy at birth, adult literacy rate, specific education, gross enrollment ratio, and GDP per capita. The advantage of this measurement of human capital is that here the concept of "human development" is being considered, assuming that the concept of development includes both quantitative growth and qualitative progress [23].

Regarding the measurement of innovation, the use of patent applications seems quite reasonable and does not require much explanation. It is a commons sense that unless "a real invention", i.e. something in the form of a unique or novel device, method, composition or process, it cannot be granted an intellectual property right. And finally, the proportion of innovative firms within a country can be considered as an enough trustworthy indicator for the innovation activities within its boundaries.

5. DATA ANALYSIS

What still remains under question is whether innovation exerts effect on human capital accumulation. Although, many would argue that the reverse is true, I attempt to prove that both are correlated.

Going back to the Shumpeterian theory of Creative Destruction one can easily see that this correlation is clearly outstanding. Schumpeter distinguishes four basic stages in the Creative Destruction Cycle – status quo, invention, innovation and imitation. So, if we take a deeper look at the invention stage of this cycle, it is quite intuitive to realize that in the core of this stage lies human capital. The more educated, experienced, trained and knowledge oriented the people are, the higher the likelihood of an invention to take place is. Of course, as MRW interpret human capital in the form of primary and secondary school we can hardly measure this likelihood. Obviously, not every graduate has the potential to become an inventor. But the probability of an invention to be made as a consequence of the work of the research and developers is much higher. So, to the extent that in order to become an R&D worker one needs a certain level of education, this makes much more sense. And for sure the more developed nations in terms of HDI possess higher chances as well. Looking from the other perspective, the one of the innovation's point of view - the results from the latter are reflected in it. Undoubtedly, the output of the researchers' work and a higher value of human development lead to an increased number of patents and greater proportion of innovative firms.

Let's now take a look at these relationships through the prism of this particular study, namely the reverse relation innovation - human capital accumulation. In order to give economic value of the invention, the entrepreneur takes the lead and performs the transformation. Circulating through the cycle the status quo is finally reached. However, it is not the same as the one before; it is already a higher one.

Taking into consideration all of the above we practically obtain a new starting point where the process for generation of the next invention starts from. But this can happen only if something in the status quo is changed for the better which immediately requires some improvement or a totally concept to be introduced. Doesn't this indicate a greater human development? And doesn’t the presence of innovation during the previous loop affect this?

Let's think about mobile phones. Would somebody be able to imagine a century ago that he wouldn't need to go to the closest post office or telegraph in order to reach someone else? Probably not. After a certain period of time human knowledge reached a level at which humans were able to apply this knowledge, so that they could invent the stationary phone. Did this invention later transformed into innovation raise the so-called human developed index? Well, without having the stationary phone at the first place would anybody come up with the idea that people need a mobile phone when actually anybody wouldn’t know what a phone is? Thus, the probability to invent the mobile phone tends to zero. This means that human capital accumulation is being observed following each and every innovation.

In order to test this hypothesis I collected cross country data for 23 countries within a threeyear-time period. To test empirically whether the two major factors—proportion of innovative firms and overall patent applications—have a role of determinants I use the above-described logic which can be mathematically transformed in the following form:

$$HCAi = f\ (PIFi, PAi, ui) \quad (1),$$

where:

- HCA_i is the Human Capital Accumulation in country i,
- PIF_i is Proportion of Innovative Firms in country i,
- PA_i is the number of Patent Applications in country i,
- HDI_i is the Human Development Index in country i,
- RDP_i is the R&D Personnel in country i,
- u_i combines all the other factors with potential impact on RDP_i

Then, I assume that the function is linear and can be written as:

$$HCA_i = ß_0 + ß_1*PIF_i + ß_2*PA_i + u_i, \quad (2),$$

Following the selected data, I use two measures for HCA and run regressions using Ordinary Least Squares:

$$RDP_i = ß_0 + ß_1*PIF_i + ß_2*PA_i + u_i \quad (3),$$

$$HDI_i = ß_0 + ß_1*PIF_i + ß_2*PA_i + u_i \quad (4),$$

The results are summarized in Table 2 and Table 3.

Three out of four models turn out to be significant leaving the one reflecting the relation between R&D personnel and the proportion of innovative enterprises out of the picture. But more important is the fact that all the coefficients are highly significant.

What immediately can be observed is that there is a good fit of a bit more than 62% and almost 57% of explaining the effect innovation exercises on human capital. Even a better one is observed in the fourth regression measuring the impact of innovation in the form of R^2. Slightly above 75% of the moments can be explained in this case.

6. CONCLUSION

The common innovation infrastructure - including a country's overall science and technology policy environment, the mechanisms in place for supporting basic research and higher education, and the cumulative "stock" of technological knowledge upon which new ideas are developed and commercialized, leads to continuous development of human capital.
As a conclusion, it may be stated that a potential impact of innovation activities is notable and further research on the topic needs to be made. The hypothesis that human capital accumulation is influenced by innovation is not rejected leaving space for further development and investigation of the concept.

Country	HDI Value	Total R&D Personnel in all Sectors	Proportion of Innovative Enterprises	Patent Applications to the EPO
Netherlands	0.921	116 666	56.7	3337,976667
Germany	0.92	579 200	79.3	22866,86333

Ireland	0.916	22 791	59.5	335,8066667
Sweden	0.916	81 272	59.6	2599,113333
Denmark	0.901	55 711	54.7	1200,79
Belgium	0.897	65 979	60.9	1394,216667
Austria	0.895	63 682	56.5	1639,403333
Lithuania	0.818	10 675	34.5	10,65333333
Finland	0.892	54 047	56.2	1279,16
Slovenia	0.892	15 333	49.4	129,9466667
Spain	0.885	208 831	41.4	1498,833333
Romania	0.786	27 650	30.8	31,94
Italy	0.881	233 927	56.3	4385,216667
United Kingdom	0.875	358 045	44.3	5185,413333
Czech Republic	0.873	60 223	51.7	188,96
Cyprus	0.848	1 270	46.2	14,50333333
Malta	0.847	1 490	41.5	6,65
Slovakia	0.84	18 127	35.6	30,57666667
Hungary	0.831	35 732	31.1	181,11
Poland	0.821	90 716	28.1	97,91666667
Portugal	0.816	56 192	60.3	282,8266667
Croatia	0.805	10 368	42.4	23,57666667
Bulgaria	0.782	16 746	27.1	15,28666667

Table 1: Cross Country Measurements (Source: Eurostat, World Bank)
The survey reference period covers the three years from 2008 to 2010

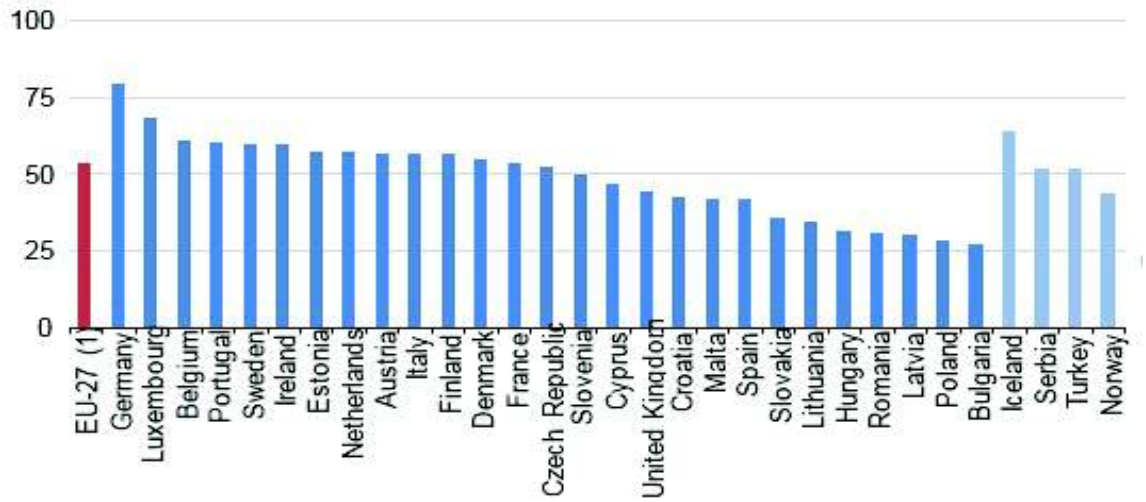

Figure 1: Proportion of innovative enterprises, 2008–10 (Source: Eurostat (online data code: inn_cis7_type))

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Constant	-0.698194	0.0901834	-7.7419	<0.00001	***
Proportion_of_innovative_enterp	0.143487	0.0234626	6.1156	<0.00001	***
Adjusted R-squared	0.623289				

Constant	-0.24419	0.0188704	-12.9404	<0.00001	***
Patent_applications_to_the_EPO	0.0169651	0.0030925	5.4859	0.00002	***
Adjusted R-squared	0.569429				

Table 2: Regression results for HDI value. Dependent variable: HDI_value

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Constant	3.18591	4.10246	0.7766	0.44606	
Proportion_of_innovative_enterp	1.93489	1.06732	1.8129	0.08417	*
Adjusted R-squared	0.094145				
Constant	7.39672	0.4205	17.5903	<0.00001	***
Patent_applications_to_the_EPO	0.566382	0.0689119	8.2189	<0.00001	***
Adjusted R-squared	0.751555				

Table 3: Regression results for R&D personnel in all sectors. Dependent variable: total R&D personnel in all sectors

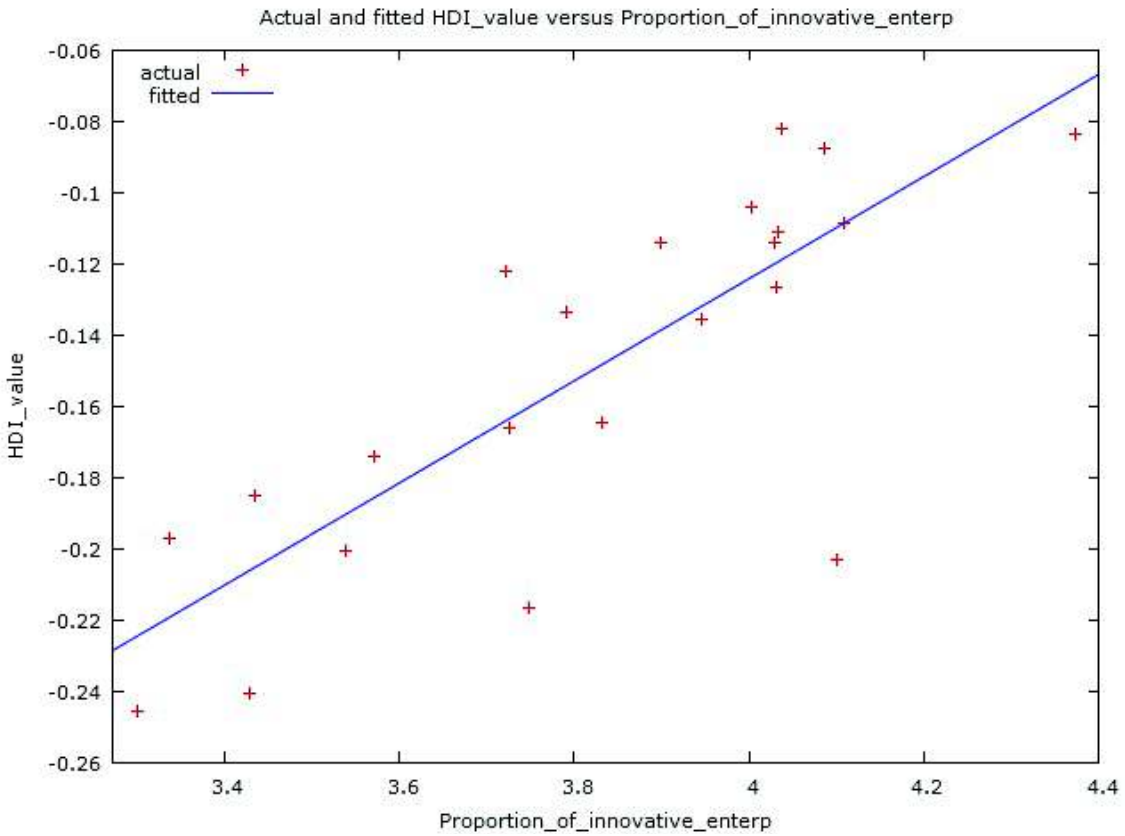

Figure 2: Actual and Fitted HDI Value versus Proportion of Innovative Companies

REFERENCES

[1] Abramovitz, M. (1956) *Resource and Output Trends in the United States since 1870,* American Economic Review 46 (May), pp. 5-23.

[2] Solow, R. (1956) *A Contribution to the Theory of Economic Growth*, Quarterly Journal of Economics, 70, pp. 65-94.

[3] Romer, P. (1990) *Endogenous Technological Change*, Journal of Political Economy, 98, pp. - S71- S102.

[4] Aghion, P., Howitt, P. (1992) *A Model of Growth through Creative Destruction*, Econometrica, 60, pp. 323-351.

[5] Metcalfe, S., Foster, J., Ramlogan R. (2003) *Adaptive Economic Growth*, CRIC Discussion Paper N. 59.

[6] Crespi, F. (2004) *Notes on the Determinants of Innovation: A Multi-Perspective Analysis*, Working Papers, 42, Fondazione Eni Enrico Mattei, pp. 7-10.

[7] Schumpeter, J. (1939) *Business Cycles: a Theoretical, Historical and Statistical Analysis of the Capitalist Process,* New York: McGraw-Hill, pp.75-88.

[8] Falkinger, J., Zweimüller, J. (2000) *Learning for Employment, Innovating for Growth*, Journal of Institutional and Theoretical Economics Vol. 156, No. 3, pp. 455-472

[9] Mincer, J. (1994) *Human Capital: a Review,* Labour Economics and Industrial Relations: Markets and Institutions, Harvard University Press, pp. 109-141.

[10] Becker, G. (1964) *Human Capital*, 2nd edition, Columbia University Press

[11] Mincer, J. (1957) *A Study on Personal Income Distribution*, PhD Dissertation, Columbia University, New York

[12] Schultz, T. (1961) *Investment in human capital*, AER 51, pp. 1–17

[13] Mankiw, N., Romer, D., Weil, D. (1992) *A Contribution to the Empirics of Economic Growth*, The Quarterly Journal of Economics, Vol. 107, pp. 407-437

[14] L S Goh, A. (2004) The Innovation Journal: The Public Sector Innovation Journal, Volume 10(3), article 34, 23. innovation.cc/volumes issues/goh_innov_driven_econo2a.pdf

[15] Salamon, M. (1991) *Human Capital and America's Future*, Baltimore, Johns Hopkins University.

[16] Romer, M. (1990) *Endogenous Technological Change*. Journal of Political Economy, 98(5), pp. 71–102.

[17] Wolf, A. (2002) *Does Education matter? Myths about Education and Economic Growth*, London, Penguin

[18] Ashton, D., Green, F. (1996) *Education, Training and the Global Economy*, Cheltenham, Edward Elgar.

[19] Blakey, T., Lochner, K., & Kawachi, I. (2002). Metropolitan Area Income Inequality and Self-Rated Health: A Multi-Level Study. Social Science and Medicine, 54, 65–77..

[20] Veenstra, G. (2001). Social Capital and Health. Canadian Journal of Policy Research, Spring, 72–81.

[21] Veenstra, G., et al. (2005). Who You Know, Where You Live: Social Capital, Neighbourhood and Health. Social Science and Medicine, 60, 2799–2828.

[22] Wilson, K., et al. (2004). Linking perceptions of neighbourhood to health in Hamilton, Canada. Journal of Epidemiology and Community Health, 58, 192–198.

[23] The 3rd OECD World Forum (2009) on "*Statistics, Knowledge and Policy*" Charting Progress, Building Visions, Improving Life Busan, Korea