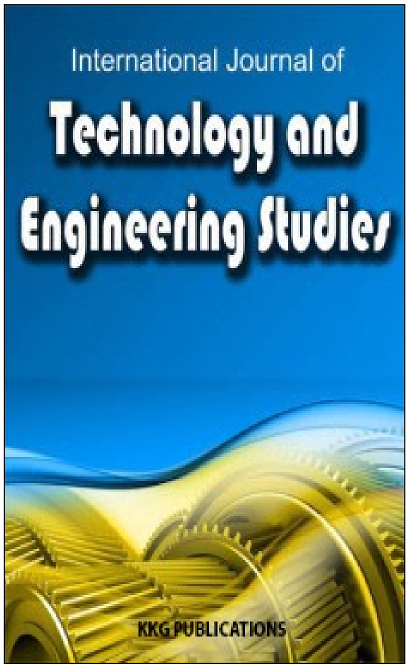

Key Knowledge Generation
Publication details, including instructions for author and subscription information:
http://kkgpublications.com/technology/

Usage of the Analogy of Space-Time in Forecasting Changes in Employment in Knowledge-Intensive Services Sector in Poland

MAREK SZAJT [1], MARCIN ZAWADA [2]

[1, 2] Czestochowa University of Technology, Czestochowa, Poland

Published online: 15 April 2017

To cite this article: M. Szajt and M. Zawada "Usage of the analogy of space-time in forecasting changes in employment in knowledge-intensive services sector in Poland," *International Journal of Technology and Engineering Studies,* vol. 3, no. 2, pp. 59-64, 2017.
DOI: https://dx.doi.org/10.20469/ijtes.3.40003-2

To link to this article: http://kkgpublications.com/wp-content/uploads/2017/3/IJTES-40003-2.pdf

KKG PUBLICATIONS

International Journal of Technology and Engineering Studies
vol. 3, no. 2, pp. 59-64, 2017

IJTES

USAGE OF THE ANALOGY OF SPACE-TIME IN FORECASTING CHANGES IN EMPLOYMENT IN KNOWLEDGE-INTENSIVE SERVICES SECTOR IN POLAND

MAREK SZAJT [1]*, MARCIN ZAWADA [2]

[1, 2] Czestochowa University of Technology, Czestochowa, Poland

Keywords:
Innovation
Knowledge-Intensive Services
Spatio-Temporal Analogy

Received: 21 September 2016
Accepted: 10 January 2017
Published: 15 April 2017

Abstract. The objective of this study was to analyze hypothetical employment in sectors of intensive knowledge in Poland in the coming years, assuming a similar course of these changes compared to other European countries. In this paper, the method of forecasting based on Spatio-temporal analogies of Knowledge Intensive Services (KIS) employment was proposed. KIS has been treated as an indicator of innovative development. EUROSTAT database has been used in the analysis. The resulting short-term forecasts indicate a likely change in employment in this sector in the coming years. This information, although expected, is significant. Analysis of the economic situation within the development of new technologies could suggest faster employment growth. The presented method of forecasting based on spatiotemporal analogies will enable short and medium-term forecasting of economic phenomena and help the concerned agencies.

INTRODUCTION

Among indicators pointing to economic innovation, one of the most observed in recent times is innovation. It is usually defined as the ability to create-from inception of the idea to its delivery to the market [1]. Its impact on the economy is huge. It is through innovation that new areas or sectors of the economy are developed, increasing their competitiveness, efficiency and productivity. Every innovation entails changes, which are the basis of economic, but also social development. Innovations shape today's society by changing the lifestyle, culture and social relations.

Among the main determinants of innovation, the following two basic factors are nowadays mentioned-financial and human resources. The first is usually analyzed in terms of funding sources and places of execution. It is also necessary to have return investments in the form of capital investment-spending on side of public for purchase of newly created products [2]. Human resources are analyzed as necessary for innovation-researchers, technicians, generally creators-and critical mass needed to absorb knowledge and technique, technology, innovation in the form of appropriately educated society, susceptible to new ideas. Due to economy turbulence and increasingly rapid changes within the sectors related to innovation, economic analysis in some areas is not easy. This is mainly the result of lack of data because of short series of observations. Therefore, the spatial and spatio-temporal analyses are more and more commonly used [3], [13].

Assumptions about similar shape of changes and relations in various areas over time are adopted. One of possibil ities used in these types of analyses are spatio-historical analogies. It is assumed that course of phenomenon similar to studied area has been observed somewhere before, so it can be extrapolated to changes to tested object [4]. To minimize potential fluctuations arising from characteristics of similar economy, possible large number of similar economies-objects with corresponding weights of their share in approximation-are used. In this article, the goal was to analyze hypothetical employment in sectors of intensive knowledge in Poland in coming years, assuming a similar course of these changes in comparison to other European countries.

Innovations and Knowledge-Intensive Service

For some people innovation is a synonym of production, which is "successful, assimilation and exploitation of novelty in economic and social fields" [5], so it is past in nature. Innovation in this sense can be discussed after "diffusion of primary process" within the meaning of popularization. Some, however, go further and recognize the innovation process by which the production resources are expanded and used to generate a higher quality and/or lower production costs than were previously possible [6]. With time, the company created by knowledge is then transferred outside, allowing to redefine problems and their solution [7], [15]. In this perspective, man is necessary at every stage of innovation. It must be a person endowed with

*Corresponding author: Marek Szajt
†Email: marszajt@zim.pcz.pl

certain talents and relevant expertise. According to [8], [14] innovation is the process in nature and consists of five phases; defining the problem, research (in both stages, researchers are indispensable), development, commercialization and diffusion of concept, effects [8] (here technicians, designers, and finally marketers are more often used).

Human factor is the key in business innovation. On the basis of enterprise, human resources are clearly the most important factor in the process of innovation [9]. First, it is a man, who is a recipient of innovation; without man there is no need to create. Secondly, innovation already existing can be distributed without funds [10]. Thirdly-and perhaps most importantlyit is a man, who is a carrier of information, idea, innovation concept, and often main contractor.

Younger and better educated society is more prone to innovation in comparison with aging population with low level of education. Regarding the structure of residence, it is increasingly marginalized due to development of electronic means of communication and a very dynamic development of transport. From the supply perspective, a person is present in virtually every stage of innovation.

Currently, the global economy is consistently moving away from agriculture and manufacturing towards services. Of course, these two sectors occupy an important-but relatively constant position in the economy. A specific measure of development, however, is the share of services in GDP formation-especially modern services generally qualified as knowledge-based services. This area attracts most new products, innovation, and is characterized by a high rate of return.

Significant increase has been observed in KIS employment in Europe in recent years. Between 2008 and 2014 the share of employment in KIS in the EU increased on average by 0.81% (Eurostat). This picture, however, is too aggregated. Analyses for individual countries indicate that this share increased in half of studied countries by not less than 1.5%.

Fastest can be noticed obviously in weaker countries, whose economies are steadily catching up forefront - or at least trying to make contact with it. In Croatia, the average increase was 3.39%, in Portugal 2,755% and in Estonia 2.47%. On the other hand, in Italy, the level is relatively constant, as in the Netherlands. The lowest level of employment in KIS sector has been observed in Romania 19.5% and Bulgaria 27.8%. Next place with 29.65% is occupied by Poland.

It is worth noting that while in Poland and Bulgaria, average annual employment growth of over 1.6%, in Romania it is only 0.26%. Largest share of employment in KIS has been observed in Luxembourg 60.4% and in Belgium, Ireland, Malta, Sweden and the UK this share exceeds 42%. Given the average level for the European Union at 36%, we think that Polish economy should reach at least this level in the shortest period possible. Assuming that current changes are persistent, this level could be achieved in 2027 and escaping EU could be reached in 2039. Especially the first level does not seem to be very unachievable however it is characterized by a certain error.

We assume, that situation in Poland will not change for the next several years, while situation in other countries operating in the same markets has impact on Poland. On the other hand, it is assumed that on average, the situation in the Union will be stable, and as we well know, it is becoming more and more distant from stability. To obtain more reliable information on employment in KIS sector, spatio-historical analogy will be used.

METHOD AND MATERIALS

One of the techniques available for use in prediction based on related data is spatio-temporal analysis. Generally, this method is based on the assumption of similarity of certain economic and social processes in different countries (societies, organizations).

A feature distinguishing objects is the starting point of process, its progress dependent on specific factors typical for a given object, and the pace of change dependent on similar determinants. We can assume that the process of development of tourism in different countries follows a similar development path, and the starting point (often also the level of phenomenon) depends on individual factors.

In modelling based on spatio-temporal analogy, we consider some kind of patterns, selected according to the following criteria:

- Establishing a set of objects with which data can be taken as a reference for projected object,
- Determining the level (point) of reference-last observed for the forecasted object,
- Analysis of similarity level and / or the shape of time series.

Similarity of examined processes is usually analysed using the measure of similarity measures of functions, for example, according to the assumption: Similarity measure of functions f and g in ranges P1 and P2 for fixed divisions is determined by the number:

$$m = \frac{1}{n}\sum_{i=1}^{n} m_i$$

where:

$$m_i \begin{cases} 1 - \frac{2}{\pi}\alpha_i \quad dla \quad 0 \leq \alpha_i \leq \frac{\pi}{2} \quad \text{(situation I)} \\ -\frac{\alpha_i}{\pi} \quad dla \quad \frac{\pi}{2} < \alpha_i \leq \pi \quad \text{(situation II)} \end{cases}$$

α_i - radian measure of the angle between straight line through points (a_i, f(a_i)), (a_i+1, f(a_i+1)), and the line through (c_i, g(c_i)), (c_i+1, g(c_i+1)).

Measure of function similarity:

Let f be a function in the range of P_1 = [a,b], g is a function defined in the interval P_2 = [c,d] (intervals P1 and P2 are of the same length). Intervals P_1 and P_2 are divided into sections of the same length

$$a = a_1 < a_2 < a_3 < .. < a_n + 1 = b; c = c_1 < c_2 < c_3 < .. < c_n + 1 = d$$

There are two possible situations:

- I function of the same monotonicity (in a section of number i division)

$$(f(a_i + 1) - f(a_i))(g(c_i + 1) - g(c_i)) \geq 0$$

- II functions of different monotonicity (in a section of number i division)

$$(f(a_i + 1) - f(a_i))(g(c_i + 1) - g(c_i)) < 0$$

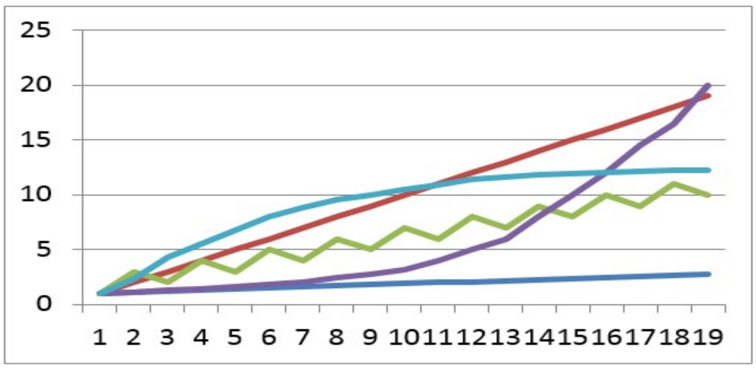

Fig. 1. Functions of the same monotonicity

Similarity measure describing primarily the monotonicity of function has several disadvantages (Figure 1). Functions, despite similar monotonicity, may have a varying volatility of the course or a different shape, which is important for forecasting, even in the short term. Literature proposes therefore to use the Pearson correlation coefficient as the measure of similarity.

However, attention should be turned to some important aspects of its use in the study of the similarity of objects. Main disadvantages include:

- Inability to determine the coefficient of data with unusual observations-because of the inability to quantify the arithmetic mean which is the basic component of correlation coefficient. This is the issue in many measures.
- Impossible to use in case of non-rectilinear interaction.
- Relatively low sensitivity to different forms of waves of analysed process in case of sufficiently high volatility of several tested objects.

TABLE 1
THE CORRELATION ANALYSIS

Types of Function	Equal Monotonicity	r_{xy}
linear	+	1.000
linear with seasonality	+	.965
exponential	+	.904
logarithmic	+	.917

Given the above (Table 1), inference can be supplemented based on Pearson correlation coefficient with additional inference based on Theil divergence coefficient. It can be calculated using not empirical values and forecasts, but as divergence (similarity) of two strings of data corresponding with the same categories of tested object y_0 and potentially similar y_i:

$$I^2 = \frac{\sum_{t=1}^{n} (y_{0t} - y_{1t})^2}{\sum_{t=1} n y_{0t}^2}$$

An important advantage of this factor is the ability to split into three components [10]:

$$I^2 = I_1^2 + I_2^2 + I_3^2$$

These components allow to better approximate determination errors which is not the case for aforementioned Pearson correlation coefficient. First part can be determined based on classical averages, but also in the case of abnormalities - with some reserve-based on position measures-median:

$$I_1^2 = \frac{(\bar{y}_0 - \bar{y}_i)^2}{\frac{1}{n}\sum_{t=1}^{n} y_{ot}^2} = \frac{(Me_0 - Me_i)^2}{\frac{1}{n}\sum_{t=1}^{n} y_{ot}^2}$$

This measure in the basic form indicates an error resulting from the prediction method bias. In indicated application, we can speak about the match, not prediction. Another component is calculated based on the following formula:

$$I_2^2 = \frac{(S_{yo} - S_{yi})^2}{\frac{1}{n}\sum_{t=1} ny_{0t}^2} = \frac{(Q_{yo} - Q_{yi})^2}{\frac{1}{n}\sum_{t=1} ny_{0t}^2}$$

In this case, we can also apply position measures. Measure calculated this way indicates the difference in fluctuation elasticities of analysed pair of variables. Therefore, it plays a very important role in indicated application. A similar role also plays the last of measures:

$$I_3^2 = \frac{2S_{y0}S_{yi}(1 - r_{y0yi})}{\frac{1}{n}\sum_{t=1}^{n} y_{0t}^2} = \frac{2Q_{y0}Q_{yi}(1 - \eta_{y0yi})}{\frac{1}{n}\sum_{t=1}^{n} y_{0t}^2}$$

Where η is the coefficient of curvilinear correlation (or Spearman rank correlation coefficient).

Of course, use of position measures and rank correlation coefficient can be questionable, but in the absence of other possibilities, these measures may be considered relatively good approximations of classic measures. Forecasting through spatio-temporal analogies is possible thanks to proper length of time series. On the one hand, they allow to investigate similarities between the course of studied phenomena to base point, on the other allow forward forecast. One of the key issues necessary for forecasting by spatio-temporal analogy is to establish shift constants ($\Delta^{(0,k)}$) representing the difference between tested amount in a given object ($Y_t^{(0)}$) in the base year and in similar objects ($Y_t^{(k)}$) in years taken as a point of reference of similarities.

$$\Delta^{(0,k)} = Y_0^{(0)} Y_0^{(k)}$$

Weights are calculated from the relation:

$$W^{(0,k)} = \frac{m^{(0,k)}}{\sum_{k=1}^{k} m^(0,k)}$$

where: $m^{(0,k)}$ is the value of correlation coefficient for k object and analysed. On the basis of available information, partial forecasts, and then global forecasts can be made. Global forecast is formed by summarizing products of weights and known values of characteristics for similar objects in subsequent periods.

$$Y_t^{*(0)} = \sum_{k=1}^{k} Y_y^{*(0,k)} \bullet w^{(0,k)}, \text{(t=1,2,...,min } n^{(k)})$$

where $n^{(k)}$ is the number of observations occurring after the similarity range of k-th object not more than the length of this range [11].

RESULTS

In our example, we have taken into consideration share of employees in KIS in relation to all employees. EUROSTAT database has been used. We have data from 2000-2014, and data from 2000-2008 were collected in a slightly different way compared with data from the years 2008-2014.

Older data were revalued (using proportions from repeated 2008). It was assumed that for verification of goodness of fit of predictions to realities, data of ten years for Poland (2004-2013) were taken into account and for other countries ten-period strings of data.

Then, using available measures, Pearson correlation and Theil divergence coefficients for subsequent strings have been calculated, assuming that after each of them, there are at least five observations (one for verification and other four for forecasts for four years).

Countries accepted as equivalent must be characterized by high values of correlation coefficients and low divergence coefficients-especially second and third. This group includes the Czech Republic, Spain, France, Luxembourg, Portugal, Slovenia, Finland, United Kingdom, Norway and Switzerland. Variety of levels of tested coefficients for selected countries suggests that the forecast is burdened with relatively low error. For the 2014 ex post error was 0.06%, which can be considered a satisfactory value. Forecasts of employment in KIS for consecutive years for Poland are shown in the Table 2.

TABLE 2
EMPLOYMENT FORECASTS FOR KNOWLEDGE-INTENSIVE SERVICES OF POLAND IN 2015-2017

Year	2015	2016	2017
Forecast	30.2%	30.6%	30.9%

Results indicate a slow, however steady approximated growth in the number of people working in KIS. This increase in the coming years should be at the level of 1.3% per year. In recent years, the change was 1.1%. Therefore, some kind of acceleration is expected. Despite modest values of changes, they should not be underestimated. Assuming their stability, we have to deal-in the future-with a permanent change in the structure of employment in Poland. Especially, because analyzed sector is not only becoming more and more promising, but developing and effective in the economic sense.

CONCLUSION

Presented method of forecasting based on spatio-temporal analogies enables short and medium-term forecasting of economic phenomena where collected information is characterized by a short recording time. Where methods characteristic for prediction based on time series cannot be applied, identification of levels and changes of studied phenomena for other objects can be used. Key is the proper selection of similar objects. In case of this study, the similarities level of employment in KIS in Poland and several other countries is very high. Use of Theil divergence coefficient in the process of selection of corresponding objects reduces errors resulting from deviations of phenomenon level from straightness. Resulting projections indicate a steady increase in employment in KIS in Poland in the coming years. This information, although expected, is significant. Analysis of the economic situation within the development of new technologies in the world could suggest faster growth in employment. However, performed analysis somewhat restrains excessive optimism. In Polish conditions, similar to those previously observed in other countries, this increase will thus stand at around 1.3% per year.

Declaration of Conflicting Interests

There are no conflicts pf interest.

REFERENCES

[1] M. Szajt, "Research and development in the development of innovative activity in the European Union." Czestochowa University of Technology, Czestochowa, Poland, 2010.

[2] I. Turek, "Importance and valuation of intangible fixed assets in innovative activities of enterprise," *Finanse, Rynki Finansowe, Ubazpieczenia,* vol. 2, no. 61, pp. 229-238, 2013.

[3] A. Shooting, "Modeling compounds of macroeconomic data on the basis of space-time," in *The Use of Quantitative Methods in the Study of Economic and Social,* M. Zawada, Ed. Czestochowa, Poland: Technical University of Czestochowa, 2007.

[4] J. Corpataux and O. Crevoisier, "Economic theories and spatial transformations clarifying the space-time premises and outcomes of economic theories," *Journal of Economic Geography,* vol. 7, no. 3, pp. 285-309, 2007.

[5] J. Baruk, "Innovation and economic development," *Problemy Jakosci,* vol. 36, no. 7, pp. 22-31, 2004.

[6] M. O'Sullivan, "The innovative enterprise and corporate governance," *Cambridge Journal of Economics,* vol. 24, no. 4, pp. 393-416, 2000.

[7] I. Nonaka and H. Takeuchi, *Creating Knowledge in the Organization: How Japanese Companies are More Dynamic Innovation Processes.* Warsaw, Poland: Poltext, 2000.

[8] M. R. Everett, *Diffusion of Innovations.* New York, NY: The Free Press, 1995.

[9] S. Roper, J. Du and J. H. Love, "Modelling the innovation value chain," *Research Policy,* vol. 37, no. 6, pp. 961-977, 2008.

[10] Z. Ostraszewska and A. Tylec, "Expenditures on innovation and the level of innovation of the Polish economy," in *Cost Management Companies in the Context of Corporate Social Responsibility,* S. Kowalska and J. Rubik, Eds. Czestochowa, Poland: Wydawnictwo Wydzialu Zarzdzania Politechniki Czestochowskiej, 2016.

[11] K. Kukula, *Introduction to Econometrics in the Examples and Tasks.* Warsaw, Poland: PWN, 1996.

[12] E. Nowak, *Economic Forecasting: Methods, Models, Applications, Examples.* Warsaw, Poland: Agencja Wydawnicza PLACET, 1998.

[13] J. S. Na Ayutthaya, S. Tuntivivat and U. Prasertsin, "The effect of positive psychological capital and organizational climate

on service quality: The mediation role of work engagement of hotel service employees in Ratchaburi province," *Journal of Administrative and Business Studies,* vol. 2, no. 4, pp. 167-176, 2016.

[14] B. Bernik, Y. Azis, D. Kartini and B. Harsanto, "Managing innovation of SMEs in creative industry for interactive game subsector and TV and Radio subsector based on local wisdom in development of competitiveness business (Case Study SMEs in Bandung)," *International Journal of Business and Administrative Studies,* vol. 1, no. 2, pp. 49-53, 2015.

[15] T. Due Au, "Using open innovation model to enhance knowledge sharing in Vietnam University," *Journal of Administrative and Business Studies,* vol. 2, no. 5, pp. 241-247, 2016.

— This article does not have any appendix. —