On investigation the interaction between the transport sector and economic cycles

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Abstract: Nowadays, the transportation system plays a deterministic role in global economy, supporting the free motion of people and products. The transport sector is rather sensitive to condition of the global and local economy. This lecture investigates the interaction between the transport sector productivity, condition and economic cycles. There will be studied the Kitchin and Juglar cycles, Kuznets swing and Kondratiev waves. The set of indicators will be defined and applied to global (World) and local (country or regional level) studies. The objective of the lecture is to support the politicians, policy makers, governmental and company managers managing the transport sector future development by information on sector economic cycles influencing on transport demand and efficiency.

1. INTRODUCTION

Our era can be characterized by revolutionary development of new technologies, wide application of the info-communication technology and economy globalization. All these major aspects cause increasing demand in transportation system, that plays a deterministic role in global economy, supporting the free motion of people and products, has an important political role, determines the defence characteristics and depends linearly on GDP (Rohacs, 2005). As Binali Yıldırım, Minister of Transport of Turkey, President of the 2009 International Transport Forum (transport, 2009): “Without a doubt, transport is an indispensable part of this process. It provides vital distribution for production, as well as essential personal mobility, directly interconnecting businesses to worldwide markets. Transport is a key element of economic growth and competitiveness.”

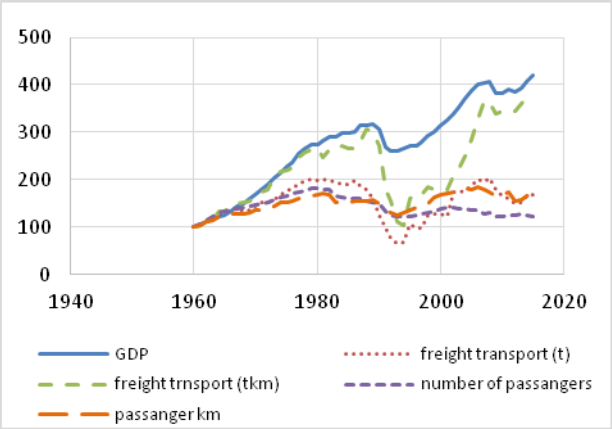

Fig. 1. Changes in Hungarian GDP and transport volumes (related to year 1960 → 100 %) (Hungarian, 2017)

Economy characterized by GDP has direct link to the freight and passenger transport as depicted in figure 1. The changes in GDP influences transport volumes.

It’s widely known; the economy developments contain some cycles. These major business cycles (Lucas, 1977, Ledenyov and Ledenyov, 2013) are called as Kitchin and Juglar cycles, Kuznets swing and Kondratiev (or Kongratieff) waves. Because the link between the economy developments and the volumes of the transportation system, the (economic) cycles must be appeared in transportation system developments, too.

This paper studies the interactions between the transport sector and economic cycles. The major economic cycles are studied, by use of a set of indicators defined and applied to global (World) and local (country or regional level) data. The objective of the lecture is to support the politicians, policy makers, governmental and company managers managing the transport sector future development by informing on sector economic cycles influencing transport demand and efficiency.

2. ECONOMIC CYCLES

The Figure 2. shows the GDP (Gross Domestic Product) of England and United Kingdom adjusted for inflation and measured in British Pounds in 2013 prices (data source: Roser, 2017). It is not so easy to use the long-term series of GDP growth for estimating the possible cyclical fluctuation in economy. Instead of this, the rate of change in GDP evident in Figure 3. is used for study the possible cycles in development. The Figure 4. demonstrates that, there are really some cycles are appearing in the business activity, in economy growth.

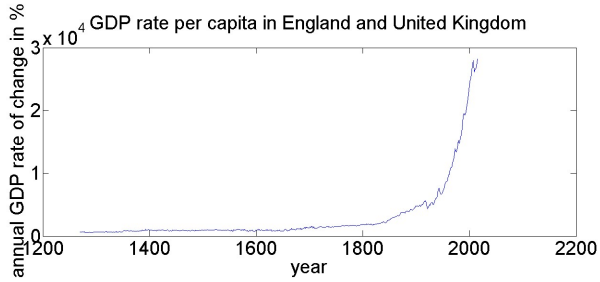

Fig. 2. UK GDP per capita history

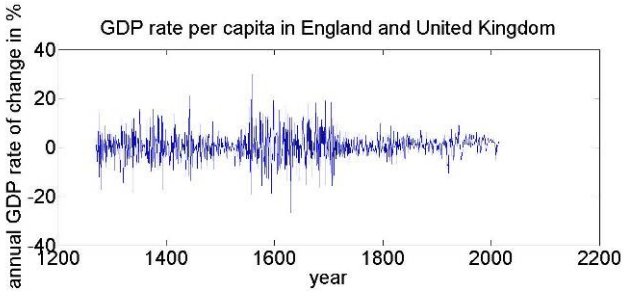

Fig. 3. Growth rate of UK GDP per capita

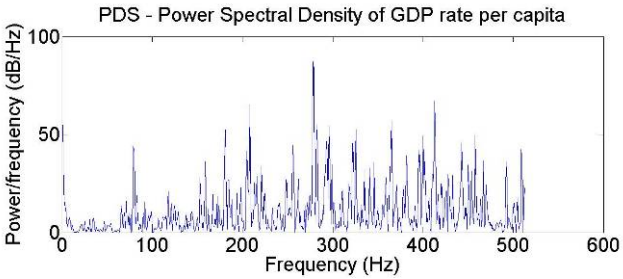

Fig. 4. DPS of UK GDP growth rate

Fluctuations appearing in Figure 4. can be characterized shifts over time between periods of relatively rapid economic growth (an expansion or boom), and periods of relative stagnation or decline (a contraction or recession) (Ledenyov and Ledenyov, 2013).

At first the business cycles were discovered by Juglar (1862). he founded the fixed investment cycle of 7 to 11 years. Later Schumpeter (1939) defining the basis of innovation theory, showed that the Juglar cycles are composed from four stages: (i) expansion, (ii) crisis, (iii) recession and (iv) recovery.

Next cycles called inventory cycles were found by Kitchin (1930). Principally, the Kitchin cycles are defined by the time lags in information movements affecting the decision making of commercial firms. These cycles long to 3 – 7 years.

The long-term cycles were investigated by Kondratiev at 1920s. He identified 45 – 60 years long wave cycle (Kondratieff, Stolper, 1935). The Kondratiev long waves are called as K-waves or supercycles, too. These waves consist of alternating intervals between high sectoral growth and intervals of relatively slow growth (Fig. 5.). A wave is building up from four stages (Kondratieff, 2017):

(i) spring when the debt level is low, consumption is low and well below incomes of corporation and individuals, while the inflation is growing slowly;

(ii) summer, the economy environment and growth are pretty good, but the inflation finally gets out of hands, interest rate may above the 10 %, making debt servicing problematic;

(iii) fall (autumn), that is the "best period", when the falling inflation and interest rates allow consumers and corporations load up debt without increasing debt servicing obligations, but before its end the increasing number of borrowers (corporations and individuals) are becoming the Ponzi units (when borrower needs a constant increase of its debt burden in order for new debt to be used to service the old debt obligations).

(iv) winter, that is a depression characterized by popping the autumn bubble while the situation is uncontrollable, deflation decreases all kind of prices, however "The main idea of Kondratieff was that the market economy self-heals itself each time it goes into trouble." (Kondratieff, 2017)

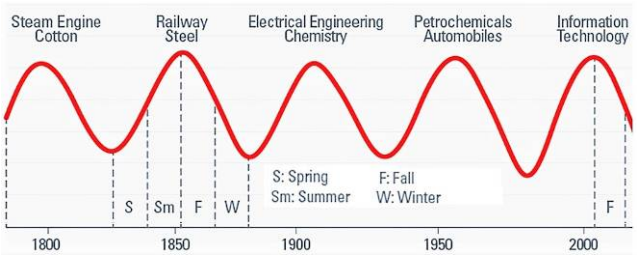

Fig. 5. The „classic" Kongratiev waves after (Edelson, 2017)

Some another interesting aspects might be underlined. (i) In Kondratiev wave, the inflation increasing during spring and summer and decreasing in fall and winter while this strange disinflation ends with absurd deflation. (ii) The stocks and bonds are moving in the same direction in the first three periods of Kondratieff wav, while during the fourth stage, the stocks and bonds are moving in opposite directions. (iii) The whole Kondratiev wave is one big credit cycle, starting with outstanding credit levels, when the authorities are forced to increase the monetary base by printing money, and after 50 – 70 years growth it ends with absurd credit levels and then everything collapses with massive defaults

The fourth business cycle was discovered by Kuznets (1930), investigating the cyclical fluctuations of the production and prices. This cycle is called as Kuznets swing: 15 – 25 years infrastructural investment cycle.

It seems the Kuznets swing is not an independent cycle, because it is appearing as a third frequency harmonic of the main frequency oscillation, which is generated by the Kondratiev long wave cycle (Korotayev and Tsirel, 2010).

The business cycles as the periodic processes can be characterized by the amplitude, frequency or period and phase parameters.

Finally, after Shcumpeter (1939) classification, nowadays, 5 business cycles are defined: 1.) 3 – 7 years Kitchin inventory, 2.) 7 –11 years Juglar fixed investment, 3.) 15 – 25 years Kuznets infrastructural investment, 4.) 45 – 60 years Kondratiev long wave and 5.) 70+ Grand super-cycles (Korotayev and Tsirel, 2010).

As the cycles have not accurate periods (time intervals), the multiple origins of business cycles were proposed in macroeconomics, as fluctuations in (i) aggregate demand in agreement with the Keynes theory, (ii) credit, (iii) technological innovations, (iv) land price and (v) politics (Ledenyov and Ledenyov, 2013).

The real process of the economy developments consist mixed compositions of the business cycles. the nonlinearities in economics and financing through the missed business cycles cause nonlinear dynamics in economic developments and even result to chaos.

3. INDICATORS AND PRELIMINARY STUDIES

So called set of indictors can be defined and used for investigating the relationship between the economy and transportation systems. The indicator is a variable selected and defined to measure progress toward an objective (Gudmunsson, 2001; Rohacs et al., 2005). Values used indicators are the i*ndicator data. There are several types of indicators, namely* qualitative or quantitative, absolute or relative. As usually the indicators are defined collected, analysing the data and applying the results in i*ndicator system. Indicator framework is the* conceptual structure linking indicators to a theory, purpose or planning process. *Indicator set is* a group of indicators selected to measure comprehensive progress toward goals. Finally, the i*ndex is* a group of indicators aggregated into a single value.

It might be the most important characteristic of the indicator is its measurability. Other important features of the indicators are (i) an explicit set of categories linking vision and goals of the future; (ii) a limited number of key issues for analysis; (iii) a limited number of indicators of progress; (iv) standardized measurement; (v) they relationship to the spatial context; and (vi) ongoing assessment integrated into the decision-making.

The economic growth as usually measured by the GDP (growth domestic product). It seems as a well simple indicator, but it calculation not so definite (Landefeld, Seskin, and Fraumeni, 2008) and it contains some anomalies, because the GDP may increase by global company working for export, only, or by moving the headquarter of a large company from one state to the another one. Therefore, the economic growth can be identified by GNP (gross of national product) and other indicators as net income, unemployment rate, etc.

The transportation system maybe characterized by indicators accounting the transport volumes and works done, namely number of passengers, passengers km, ton of goods transported and tonnekm covered. The indicators maybe defined for years, months, etc., too. of course in case of investigating the impact of transport on environment, studying the sustainability, research in efficiency or cost structures, developing the infrastructure and so on, need wide range of different indicators and indexes (Gudmundsson, 2001), Rohacs and Simongati, 2007; Rigo et al., 2007), Simongati, 2010; Lahiri, 2010; Litman, 2003, 2016). for instant, Lahiri and his Collegue (Lahiri, Yao, and Young, 2003; Lahiri, 2010) used four coincident indicators (transportation service output index (TSOI), real aggregate payrolls of workers employed in the transportation sector, real personal consumption expenditure (PCE) on transportation services and all employee) for investigating the business cycles in transport. Generally, these indicators reflect information on output, income, sales, and labor usage in the transportation sector and may define the business cycles in sector. Our objective to investigate the interaction between the economy cycles (defined by use of generally and most used indicator GDP) and possible cycle in transport systems.

According to the European statistics (Statistical, 2014) the transport volume really depends on the economy level (Fig. 6.). The picture is very similar with Figure 1. As it can be seen the freight transport has greater sensitivity to changes in GDP. It is well understandable, because the transport of goods depends on the production process intensity and market pull effects that are decrease in case of economic crises.

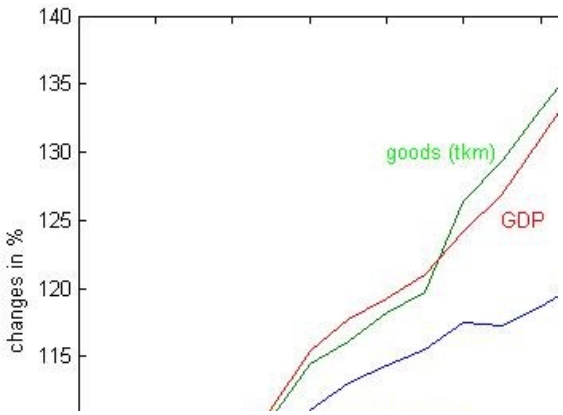

Fig. 6. The economy and transport interaction (passenger (tkm) includes all types of the passenger transport: passenger cars, powered two-wheelers, buses and coaches, tram and metro, railways, intra-EU air, intra-EU sea; transport of goods including the road, rail, inland waterways, oil pipelines, intra-EU air, intra-EU sea transport, GDP defined at constant year 2000 prices and exchange rates)

The correlation coefficient of GDP and different transport indicators (Table 1.) shows an interesting aspect of interaction of GDP and transport volumes. The tkm and pkm indicators are well correlated by changes in GDP, while volumes of the freight and passenger transport (as tonne number of passengers) are not correlated with GDP changes.

Table 1. Correlation between the economy and transport system prosperities (calculated by use of data shown in figure 1.)

I – indicators / correlation	freight (t)	freight (tkm)	passenger (number)	passenger (pkm)
(GDP(t), I(t))	0.4405	0.8357	0.0247	0.8649
(GDP(t), I(t+1 year))	0.3531	0.8130	-0.1518	0.8106
(GDP(t), I(t+2 year))	0.2446	0.7709	-0.31363	0.7272

The Figure 7. may explain this interesting aspect. In year, 2014, 74 % of freight transported by the road vehicles registered in Hungary were realized in worldwide international relations. The same indicator in Germany was only 14 %, and in Austria it was 40.4 % (Freight, 2017). So, the Hungarian road freight transport is very open, serves the global industry.

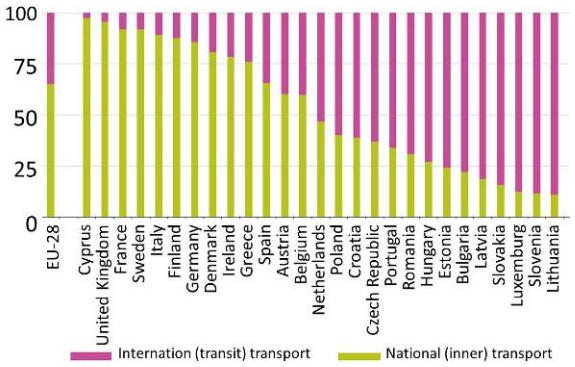

Fig. 7. Road freight transport in year 2014 (Freight, 2017)

The relationships between the economy and transport are identified in many different forms, like influence of economy development on the road transport emission and its possible reduction by managing the technological innovation (torok and torok, 2014).

According to the transport means, the air transport may have a greater sensitivity to the changes in economy, changes in global economy. The Figure 8. demonstrates that, the air transport operating margin (sometime called as operating profit margin or return on sales) really has cyclical changes and the capacity index (difference between overall capacity utilization and its 10 year moving average) follows these cycles by delay. nearly the same figure can be identified in case of study the new aircraft ordering.

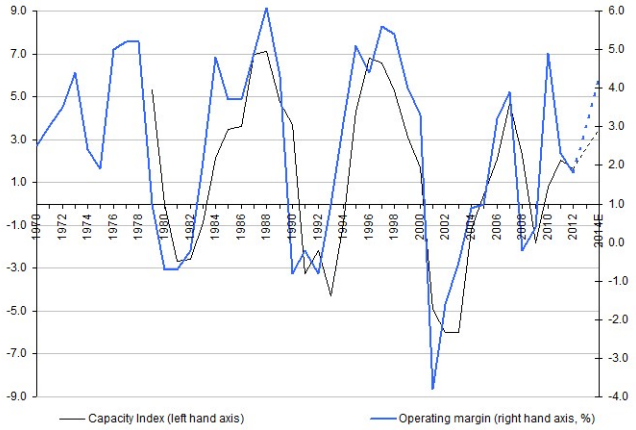

Fig. 8. Capacity Index and global airline operating margins (%) (World, 2014)

The last preliminary investigated aspect was the interaction between the technology development and business cycles. This aspect had been studied by the Schumpeter already. He drew the innovation cycle (Figure 9.) that a slightly different from the Kongratyev waves (Figure 5.). The difference is characterized by reducing the cycles period. this effect is harmonizing with the Kurcweil's law on accelerating returns. As Kurzweil (1999) defined "The Law of Accelerating Returns", the rate of change in a wide variety of evolutionary systems (including but not limited to the growth of technologies) tends to increase exponentially.

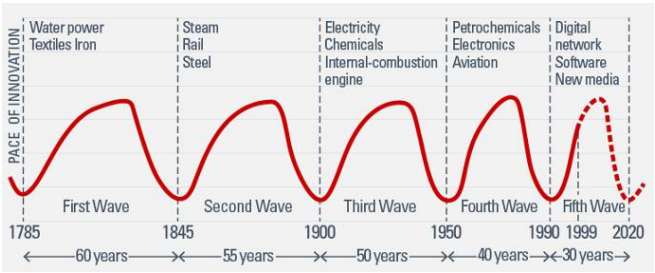

Fig. 9. The Schumpeterian cycles of innovation and entrepreneurship (Edelson, 2017)

There is an interesting fact, the innovation cycles have direct interaction with development of the vehicles and transportation systems, as railway, internal combustion engine, aviation, e-mobility.

4. INTERACTION BETWEEN THE ECONOMY DEVELOPMENTS AND TRANSPORTATION SYSTEMS

There is not a unique and standardized method for dating the business cycle. Probably, the most used cycle definition results are the NBER business cycle. NBER – National Bureau of Economic Research as it can be red on its website (National, 2017) is "private, non-profit, non-partisan research organization's main aim is to promote greater understanding of how the economy works". This organization uses a sophisticated approach to business cycle dating based not only on GDP and GDI (Gross Domestic Income as income received by all sectors of an economy within a state), but on use a range of other indicator characterizing the (domestic)

economy. Principally NBER evaluates the significant decline in economic activity defined by monthly indicators.

The NBER business cycle for period 1960 – 2009 are defined in Table 2.

Table. 2. NBER cycles since 1960

Peak month	*Trough month*	*Peak month number*	*Trough month number*	*Duration, peak to trough*	*Duration, trough to peak*	*Duration, peak to peak*	*Duration, trough to trough*
April 1960	February 1961	1924	1934	10	24	32	34
December 1969	November 1970	2040	2051	11	106	116	117
November 1973	March 1975	2087	2103	16	36	47	52
January 1980	July 1980	2161	2167	6	58	74	64
July 1981	November 1982	2179	2195	16	12	18	28
July 1990	March 1991	2287	2295	8	92	108	100
March 2001	November 2001	2415	2423	8	120	128	128
December 2007	June 2009	2496	2514	18	73	81	91

Note: Month numbers start in January 1800

Of course there are several other methods for study and determining the business cycles from the series of economic data (Long, Plosser, 1983; Baxter, King, 1999). For the investigated case, when the sector economic cycles are analyzed, probably the methods using the Markov-switching models (Hamilton, 1989; Goodwin, 1993; Smith, Summers, 2005) may result to the best solutions.

In any case, the good solutions need accurate, probably monthly and several indicators. Unfortunately, such time series for the transport sector is available in rather limited forms.

Another important fact, the economy of the developing and new democratic counties (like Hungary) the political changes have large influences on the economic developments (see early 1990s in Figure 1.).

There is an "extra" interesting problem: the indicator time series are different depending on their sources. namely the Hungarian GDP data shown in Figure 1. is different from the Hungarian GDP data published by EUROSTAT. In some years the differences in GDP rate reach the 100 – 200 %.

All these aspects introduce difficulties and barriers in evaluation of interrelationship between the economy and transport sector.

Finally, we have focused our study on processes of analogy (of changes in economy and transport sector) and we have applied the methods of statistics (autocorrelation, correlation) and methods of time series analysis available in Matlab.

The transport sector and generally the vehicle – logistics and transport system is investigated by us from several different point of view including the sustainability (Rohacs, et al., 2005; Rohacs, Simongati, 2017) demand modeling and prediction (Rohacs, D., 2007), project management (Bicsák, Sziroczák and Rohács, D. 2010) or effect of railway transport developments on economy (Kinzhikeyev, Wangai, 2017).

Our results well harmonized with the results of Lihary, Yao and young (2003) while they had investigated the interrelationship of transport and aggregate economy (based on USD data). On the other hand, the correlation matrix shown in Table 1. rather different from the results published by Torok (2017), because we studied the general transport sector, that was not divided into several sub-sectors.

Final formulation of key findings is given in conclusions.

The Figure 10. demonstrates the interrelationship between the GDP and freight transport. Here tonnekm/GDP indicator is defined as the ratio between tonne-kilometres (inland transport only) and GDP (chain-linked volumes, at 2005 exchange rates). It is indexed on 2005. It includes transport by road, rail and inland waterways. Rail and inland waterways transport are based on movements on national territory, regardless of the nationality of the vehicle or vessel. Road transport is based on all movements of vehicles registered in the reporting country.

The Figures 11 and 12 shows a connection of freight (tkm) and passenger (pkm) indicators of Hungarian transport section and changes in Hungarian GDP (Figure 11.) and EU GDP rate of change (Figure 12.).

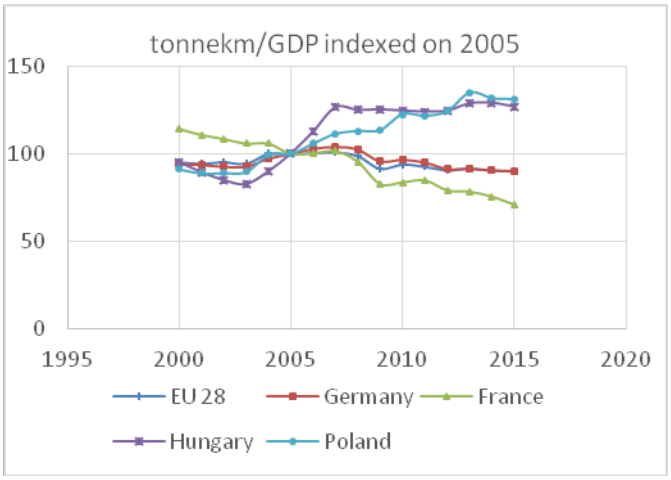

Fig. 10. Interrelation of freight transport and GDP

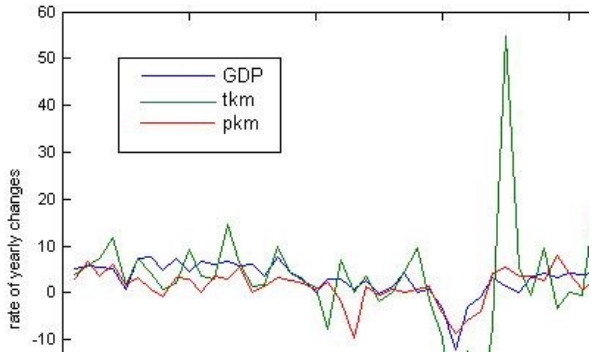

Fig. 11. Rate of changes in transport and economic indicators (Hungarian data)

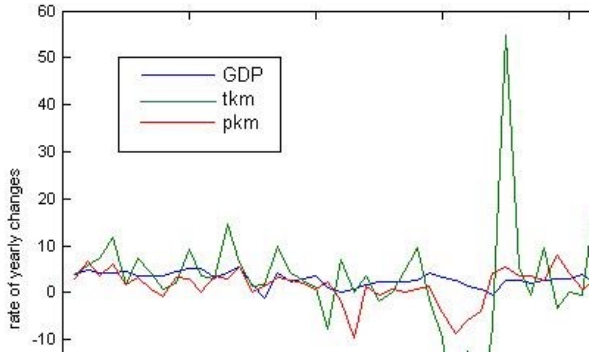

Fig. 12. Rate of change in EU GDP and Hungarian transport indicators

The Figures 11. and 12. demonstrate that,

- the political changes in Hungary (at 1989 – 1990) caused the major effect, drastically changes in transport volumes,
- the Hungarian transport productivity follows more the changes in Hungarian GDP, than changes in European economy indicator,
- the transport section of new democratic countries (as Hungary or Poland – see Figure 10., too) serve global economy and their transport volumes growth with higher rate than the European sector after 2005, therefore they had less sensitivity to the economic crisis.

5. CONCLUSIONS

This paper has investigated the role of transportation sector in economy development. Focusing on identifying business cycles in transportation sector.

The business cycle is dated by use of complex approach based actually on the economic activities more than on one or two important economic indicators, like GDP (see dating the NBER business cycles).

Unfortunately, such complex approach cannot be applied to the transport sector because of the limited historical data. Frequently used transport indicators are the volumes (tonna or number of passengers) and productivity or works done (tkm or pkm). Even such data are available only as yearly measured information. Therefore, the recommended mathematical models (as for example Markov switching) may have not given the required quality results.

This paper dealt with study the statistical characteristics (as correlation data), approximation of the available time series by Matlab, evaluation of the analogy in different comparison studies and applying the logic reasoning.

The most important conclusion are the followings:

- there is a strong interrelationship (correlation) between the economy growth and transport sector productivity,
- the relationship very considerable depend s on the changes in political situations followed by radical changes in economy,
- the open economy involves greater influence of global economy on the transport sector,
- the business cycles are diffused into the transport sectors by the following ways:
  - Kitchin cycle (3 – 5 years' periodic cycle) – as inventory cycle is appearing in transport sector as in other sector by usual way of doing the business,
  - Juglar cycle (7 – 11 years) - as fixed investment is related to changes in vehicle fleets and diversification of activities,
  - Kuznets swing (15 – 25 years) – is diffused into the transport sectors, too, however, the large investments are catalyzed more by the changes in political and economic conditions of the given countries and is catalyzed by the globalization (in economy, free motion of people, etc.) and technology developments,
  - Kondratiev wave (45 – 60 years) – has direct effect on the transport sector, because the most technological changes are deployed very quickly in vehicle and transportation system developments.

Generally, the detected effects must be verified and they need further investigation by use of more reliable, decomposed data and more sophisticated dating methodologies.

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