Cyclical Fluctuations in Transport. Turning Points Detection

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This paper presents the preliminary analysis of the characteristics of cyclical fluctuations in the freight transport market in Poland. The aim of the analysis is to identify, based on the estimated turning points (using the Bry Boschan method, as well as Hidden Markov Models), expansion and contraction phases in freight transport. These results are compared with the business climate indicators calculated on the basis of survey research in the freight transport.

Keywords: Cyclical fluctuations, transport, turning points, Bry Boschan Method, Hidde Markov Models.

1. INTRODUCTION

For a long period transport has been on a long list of economics sectors, diagnosed from the point of view of business activity and its fluctuations. On the one hand, it is due to Central Statistical Office, that carries out research on cyclical fluctuations in transport and in warehouse economy [10], on the other hand it is due to research on heavy good transport, carried out by the Motor Transport Institute. In both cases a usual tool for both research is a survey research. Basing on information from the answers to a set of questions the results of analyses are formulated. The questions refer to quality assessment of the research objects changes of situation and their economical surrounding.

The process in question let obtain information relatively easy. This information would be difficult or impossible to collect in a different way, and the data allow to diagnose, in a successive way, the state of business activity in the domestic and international motor freight transport, as well as to identify and forecast business activity fluctuation in this area. From the point of view of the present paper, it can be described as a part of *nowcasting*, which consists of economic forecasting before it has been formulated on the basis of hard macroeconomic data, very often published too late and very often needed to be revised.

Research of Polish economy cyclic fluctuations has been carried out for more than twenty years. Theoretical and particularly empirical output in this field is very significant. Among the works created over the last ten years, the ones of E. Adamowicz research team [1], [2], M. Biec [9], Skrzypczyński [13], Z. Matkowski [12] and others can be listed. The fluctuations qualities of basic macroeconomic variables have been analyzed in the works listed above, (among others GDP, added value, consumption, export, import and the level of employment). They allow to identify not only Polish economy cycles but the level of their synchronization with the economic cycles in the countries of the European Union, too. Nevertheless, it seems that the field of transport has not been the main stream of this research. An exception is M. Bernadelli and M. Dedys' work ([4]) and the book including this work [8], on soft dynamics analysis (survey) and hard characteristics of the freight transport sector in Poland.

2. DATA AND TOOLS OF THE ANALYSIS

The data come from two sources. Macroeconomic variable values, that characterize Polish economy, come from the data base of the Central Statistical Office. They cover quarterly data on GDP dynamics, value of international exchange, added value in transport, transport volume and performance. The sources of soft

characteristics of the business activity in transport are data collected in research carried out in the Motor Transport Institute ([3]). These data, also collected quarterly, cover the following indicators: business activity in the domestic and the international transport, and the indicator of transport companies economic condition.

Cyclic fluctuations properties of these values have been viewed in the light of turning points (TP) position. The research was carried out in a convention of fluctuations cycles, where fluctuations refer to cyclical components separated from time series after having eliminated trends and seasonal fluctuations. Cyclical components of the time series were assigned by the means of Christiano-Fitzgerald ([7]) filter, with bandwidth from 2 to 10 years, referring to typical periods of business activity fluctuations. Turning points are understood as a series of turning points in cyclical components of these series . Upper TP correspond to a large deviation in plus of the value of the variable from its trend, lower - on the contrary. A complete cycle corresponds to the period between successive lower turning points (D) and also successive upper turning points (G) .

On the one hand, the position of the turning points was estimated by the means of Bry Boschan method, considered as the classical one([5] , [11]). The second, basic, formal tool for the analysis of size transport and economic indicators time series, is a group of models called the Markov- switching models (also called hidden Markov model, *Hidden Markov Models, HMM*, see e.g. [6]). The values of variables are treated as signals, emitted by a layer of an observable model; their probabilistic characteristics depend on specific changes in states of the hidden layer. The main problem is to find the most probable course of these changes (hidden layer trajectories), on the basis of knowledge of an observable component implementation[1]. The

trajectory, mentioned above, or, more precisely, moments, where changes in states of the hidden layer occur, define turning points in business activity. To estimate the trajectory of the hidden layer, Viterbi algorithm was used ([14]).

All calculations were performed using the procedures written in the R environment.

3. CHARACTERISTIC OF CYCLICAL FLUCTUATIONS IN MOTOR FREIGHT TRANSPORT

Transport is a sector that in fact supports all sectors of real economy. For this reason many variables can naturally be considered as a quantity describing the state of freight market, as well as its interactions with the environment.

As variable reference, value of the gross domestic product, import and export were adopted. Volume of traffic and transport performance of the domestic and international freight transport play an auxiliary role. Unfortunately, the time series of these quantities are relatively short, their role in comparisons will be therefore less important.

In the course of GDP cyclical component, 10 turning points were identified: the lower ones, in the following periods[2] 1998 (4) 2001 (4) 2005 (2), 2009 (2) 2013 (1) and the upper ones, attributable to the following periods: 1997 (2) 2000 (1) 2004 (1) 2007 (2) 2011 (2). Therefore, 4 DGD and the same number of GDG cycles in GDP fluctuations can be distinguished. The average time of the growth phase amounted to 7.5 of a quarter of a year, while the downward phase of 6.6 of a quarter of a year. The results obtained for this and other variables analyzed, are shown in figure 1.

A two-state model HMM for the cyclical component of GDP captures only the crisis that began in 2008, therefore, (which HMM models, built for other variables confirm [2]), it is useful in a moderate way in the analysis of past and future economic fluctuations. Moments of discontinuity jumps, of hidden variable trajectory (hidden Markov chain) in HMM model [3] for the size of GDP are shown in Fig. 2[3]. A regular nature of fluctuations and relatively short time of the state of extreme conditions (periods of prosperity, shown in white and periods of relatively weak business activity, shown in black) draws attention.

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[1] HMM models, in which the hidden layer is n - state Markov chain will be saved as HMM [n]. In the case of HMM models [2] interpretation states is obvious: one corresponds to a better business activity, second to a poorer one. In the case of n > 2 interpretation of the state is no longer so sharp. When n = 3 states correspond to periods of good and poor economic conditions. The last is a transition state, from which it is possible to transition for each of the previously mentioned. In the case of n = 4 is the scale of the natural kind: the situation is very good, good, positive, bad and very bad. In this paper we concentrate on cases where n = 2, 3.

[2] The number of a given quarter is put in parentheses.
[3] We present here of course information about the most probable trajectory, estimated by the means of the Viterbi algorithm.

Transition period, which separates the two periods of good and bad economic times, is relatively the longest one. Large jumps, between extreme states, can be observed easily, unfortunately it is a process which almost always is connected with economy downturn[4].

Fluctuations in export and import are simultaneous.

Upper turning points in **import** fluctuations were identified in the periods 1998 (1) 2000 (2) 2004 (1) 2006 (3) 2007 (4) 2010 (4) 2012 (4) and lower turning points in the following periods:1997 (1) 1999 (1) 2001 (3) 2005 (2) 2007 (2) 2009 (2) 2012 (1) 2013 (2). As a result, the average time of the growth phase, amounting to 5.0 quarters of a year was therefore greater than the average length of the downward phase (4.3 quarters of a year). The upper turning points of cyclic component of *export* fluctuations were identified in the following periods:1997 (4) 2000 (3) 2003 (4) 2006 (2) 2007 (4) 2010 (4) 2012 (4), while the lower ones in the years 1996 (4) 1999 (1) 2001 (4) 2005 (1) 2007 (2) 2009 (2) 2012 (1) 2013 (3). The average time for the phases of growth and decline does not differ significantly and amounts to 4.9 and 4.7 of a quarter of a year. HMM models [3] for import and export also are characterized by a large number of transitions between states, and the periods of good business activity are very short. The periods of worse economic conditions last longer, and the periods of transitional nature are the longest ones.

It is worth comparing the above information with the one from the results of survey on business activity in transport.

In the case of component cyclical indicator of business activity in the domestic transport, upper turning points were identified in the following periods: 1997 (3) 2000 (3) 2003 (3), 2007 (2) 2010 (3) 2014 (1) while the lower turning points - in the following periods: 1999 (2) 2002 (1) 2005 (2) 2008 (4) 2012 (3). Distributions of both amplitudes and the cycle times are almost symmetrical. When it comes to the cycle duration, the average time of

growth and decline phases was, respectively, 6.4 and 6.8 of a quarter of a year.

Cyclical fluctuations of *business activity indicator in the international transport* cover full 4 DGD cycles and 5 GDG cycles. The upper turning points accrue during the following periods: 1997 (3) 2000 (2) 2003 (3) 2007 (2) 2010 (3) 2013 (3), while the lower one in the following periods 1999 (1) 2001 (4) 2005 (2) 2008 (4) 2012 (1). The average time of growth and decline phase are respectively 6.6 and 6.2 of a quarter of a year.

In the course of the cyclical component of the *indicator of the transport enterprises economic condition* upper turning points: 1997 (3) 2000 (1) 2003 (4) 2007 (1) 2010 (3) 2013 (4) and the lower ones in the periods: 1999 (3) 2001 (1) 2005 (3) 2008 (4) 2012 (3) can be distinguished. The average time of the growth phase was therefore almost 6.2 quarter of a year, while the decline - 6.8 quarter of a year.
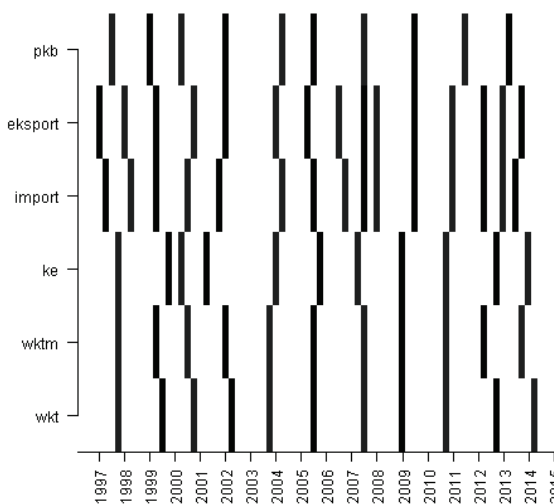

Fig. 1. Location, of turning points of selected macroeconomic variables and business activity indicators in transport determined by the means of Bry Boschan method. colour red corresponds to upper TP, black colour corresponds to lower-TP of fluctuations.

Now we compare the characteristics of the fluctuations in business activity indicators of the transport with the characteristics of the reference variable fluctuations (the size of GDP, imports, exports). The main objective is to investigate, whether fluctuations of these indicators have anticipating character. The basis of diagnosis will be average anticipation of turning points in cyclical components of the analyzed variables in relation to the turning points corresponding to the reference

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[4] It is worth to emphasize that between the turning points of the economic cycle designated with Bry Boschan method (BB), and at times switching between the states of a circuit Markov models HMM [n] there is no simple adequacy. These switches in HMM models can be so frequent, and the intervals between them short, that they will not considered as turning points by the BB procedure. Both approaches give complementary, although non-identical, characteristics of cyclical fluctuations.

variable. Of course, in order to obtain updated indicators that would be an appropriate monitoring tool, which would at the same time adequately warn of early changes in the business activity, the anticipation should be adequately long.

A desirable property is compatibility of the growth and decline phases duration, for compared variables. This requirement leads to a (smaller or larger) number of compliance indicators of turning points and the reference quantities, which allows to reduce the risk of false signals about the growth phase change to the slowing down or vice versa.

Fluctuations of business activity cyclical indicators in transport are similar in their course - they are characterized by a similar amplitude and growth and decline durations phase. This remark applies above all to the indicators based on the transport production, and to a slightly lesser extent, refers to the indicator of economic condition of the transport enterprises.
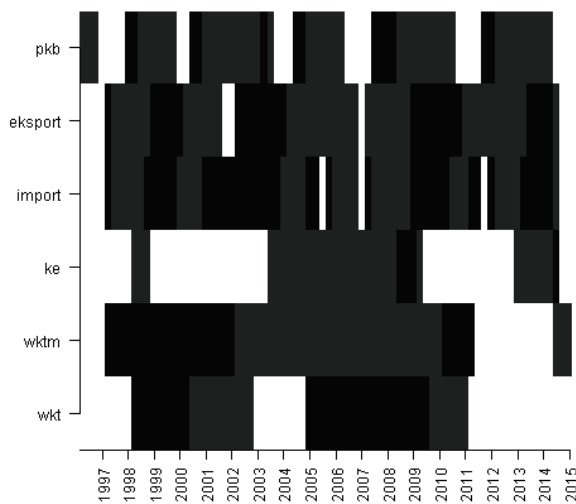

Fig. 2. The location of the switching between the states of the hidden layers of HMM models [3] for selected macroeconomic variables and business activity indicators in transport. White color corresponds to the relatively good economic situation (this period is characterized by the largest, among two following, average value of the variable cyclical component); black color corresponds to the state with the lowest average (relatively worst business activity). The red colour corresponds to the middle state.

Position of the turning points of these quantities, as well as of hard characteristics, examined above, allows to define the following periods:

- Final phase of accelerated growth in 1997 (1) - 1998 (1). In this period all the upper TP both

of hard data and of business activity indicators can be found. Additionally - in the case of import - in this period there is an earlier, lower TP. Business activity turning points indicators can be found in the middle of this period. They are simultaneous with changes in transport performance, anticipate one or two quarters of a year changes in quantity, respectively of export and import.

- Period of 1998 (3) -1999 (3). The end of slowing down and the beginning of growth. TP business activity indicators fall on the second half of the period and are usually delayed in relation to the lower TP of other variables.
- Period of 1994 (4) -2000 (3). TP of business activity indicators differ among themselves and have the nature of a simultaneous change in GDP and exchange with foreign countries.
- Period of 2001 (1) -2002 (1). The transition between the phase of slowdown and accelerated growth. The fastest signals of the period are TP indicators of business activity. Other indicators can be considered as simultaneous with hard characteristics.
- Period of 2003 (1) -2004 (1). Business activity indicators rank in the middle of this period, like TP quantities of transport performance. Anticipation of GDP and exchanges with foreign countries is 1 quarter of a year. The exception is the dynamics of value added in transport, where we note a short period of slowdown, ended by an early lower turning point.
- Period of 2005 (1) -2005 (3). Beginning of the acceleration phase. Business activity indicators are simultaneous with GDP, import and export volume. Dynamics of transport performance has different character. Additional upper and lower TP occur in this and the following period, which results in greater fluctuations frequency. It coincides with a period of takeovers by road transport (from the railroad) a large amount of bulk cargo. It seems, however, that these changes are not clearly highlighted by business activity indicators.
- Period of 2008 (4) -2009 (2). The lower TP of all hard characteristics signalled earlier by business activity indicators.
- Period of 2010 (3) -2011 (2). The beginning of the slowdown phase signalled by business activity indicators in transport.

- Phases 2012 (1) -2013 (4). Frequent fluctuations in import and export are not synchronized with changes in business activity indicators. TP of the latter ones anticipate their changes in GDP growth and in the size of transport performance.

HMM models [3] constructed for economic indicators in transport are characterized by visibly smaller number of switches and a longer residence time in extreme conditions (better and worse business activity). Moments of switching between the states are not overly well-matched to the turning points obtained by the means of Bry Boschan method. Their location is not similar to the location of the turning points of reference variables either. The position of the turning points of obtained by the means of BB method allows the hypothesis, that fluctuations of business activity indicators in transport and reference variables (especially GDP) have essentially simultaneous nature. Given the delay in the publication of hard statistical data and their frequent revisions, it can be concluded that business activity indicators in transport are natural components of business activity indicators. These indicators are also the promising regressors for many prognostic models. Unlike to the position of the turning points obtained from the BB method, the positions of switching points in the HMM models [3] for business activity indicators and reference variables are significantly different. Perhaps it results from the fact, that too small number of hidden Markov chains states was taken into account. It is worth to expand the analysis to the larger number (in the HMM models [4] states their natural interpretation would close in the following terms: prosperity, relatively good, relatively weak, weak), or to modify the components of the same HMM model (another family of answers functions, another model for probabilities of transition, or selection of different regressors).

However the presented results are encouraging.

4. FINAL REMARKS

Fluctuations of business activity indicators, observed until present, allow to say, that they have had relatively good prognostic properties, particularly over the last 10 years. This statements refers mainly to the location, identified by the means of Bry Boschan method, business activity TP indicators according to their equivalents in cyclical components of GDP fluctuations.

Fluctuations of business activity indicators seem to have also a parallel character with fluctuations of international exchange. Considering that fact, that information on business activity value is published faster than other macroeconomic data, and considering, that they are not later revised, it seems rationale to claim that observation of such data can be an important source of information. It can be helpful in the process of formulating conclusions on business activity changes on the scale of the entire economy. Business activity indicators seem to be thereby a proper element in a set of business activity indicators for economy.

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