DYNAMIC ECONOMETRIC MODELS
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Notes on a Forecasting Procedure

1. Introduction

The proposed forecasting procedure has been developed as a tool of integrating indicators derived from business tendency surveys with selected indicators of quantitative statistics, in order to improve the diagnosing and forecasting of the economic tendencies in Poland[1].

Looking at business tendency surveys based on the philosophical background of the business cycle theory one must note that opinions formulated at the enterprise level are growing in significance in the economy, whose nature is microeconomic in fact (Kokocińska, Strzała, 2007). An overview of the literature reveals (Carnot, Koen, Tissot, 2005) that about 14 research institutions dealing with economic forecasting world wide include the business surveys results in their analyses and projections[2].

The analyses focused on the Polish economic tendency indicators and their integration in the conducted surveys, including the qualitative indicators derived from the business surveys and macroeconomic time-series sourced from Statistical Bulletins and materials available from the Department of National Accounts, Central Statistical Office.

2. The Survey Procedure

The preliminary phase in the procedure consists in evaluation of the stochastic structure of the data generating processes (DGP) of the analysed vari-

[1] The article is a part of research conducted within a project H02C 054 27 '*Integrated system of evaluation of enterprises' business activity*', supervised by Małgorzata Kokocińska, Economic Academy, Poznań.

[2] See Kokocińska, Strzała (2008).

ables. Using quarterly time-series, the stationarity analysis is conducted to test the presence of the long-term unit root and evaluate the types of the occurring cyclic fluctuations, including seasonal. The ADF[3] test and the reversed ADF test proposed by Leybourne[4] were employed to identify the order of long-term integration. The HEGY[5] test and the critical value tables developed by Franses and Hobijn[6] were used to verify the hypotheses of the occurrence of seasonal unit roots. The discussed part of analysis was conducted under the procedure proposed by da Silva Lopes (da Silva Lopes, 2003; Blangiewicz and Strzała, 2006).

Then, depending on the order of variable integration two different procedures were proposed: for stationary variables of the I(0) type, and for non-stationary series type I(1). In both cases the cross correlation analysis and the Granger's[7] causality tests constituted the intermediary stage for series sharing the same order of integration[8]. Two-equation vector autoregressive models (VAR) were proposed to form the basis for arriving at the forecasts and their evaluation. These were stationary for series of the I(0) type, or co-integrated (VECM)[9] whenever any significant long-term relations were identified between the macroeconomic series and indicators of the business tendency survey.

The proposed econometric procedure involves the following stages[10]:

I. Log transformation of the macroeconomic variable series.

II. Seasonal adjustment and analysis of the stochastic structure of time-series.

III. Computation of cross-correlations (leads and lags up to 7 quarters).

IV. Granger causality test and generation of dynamic forecasts for stationary variables (I(0))

VI. Granger causality test and generation of dynamic forecasts for I(1) variables

VII. Evaluation of the relative ex-post errors, and final assessment of the usefulness of the business survey indicators.

In the paper we shall waive describing the standard components of the above-presented procedure focusing only on those elements which have not yet joined

[3] Detailed description of non-stationarity testing rules can be found in e.g. Charemza, Deadman (1997), Strzała (1994).

[4] See Leybourne (1995).

[5] See Hylleberg (1992).

[6] See Franses and Hobijn (1997).

[7] See Granger (1988).

[8] Such approach has been advocated by e.g. Toda, Yamamoto (1995).

[9] VECM – Vector Error Correction Model, see Johansen (1988).

[10] Computations have been done with the use of the econometric packages: **gretl**, Microfit and GAUSS. Sesonal adjustment was performed with DEMETRA (TRAMO/SETS modules).

the cannon of the econometric procedure, or are arguable in the discussed context. These include the causality tests.

Exhaustive comparisons of the stochastic characteristics of causality tests can be found in: Geweke (1984), Guilkey and Salemi (1982). The most recent proposals in this respect include the path analysis of the causality structure of multidimensional time-series[11], or the posterior odds ratio test combined with the portfolio approach to evaluation of the causality test results. In the survey we used the Granger block non-causality test for (recursive) blocks[12] of equations.

The key issue in practical applications consists in evaluation of the test results when the analysed processes are non-stationary, and this is exactly to be expected in economic applications. Pursuant to the assumptions formulated by Granger the variables should be stationary, and no autocorrelation should occur. The experience accumulated over more than 40 years indicates that non-stationarity can be neutralized by including the deterministic trend and/or log transformation. Autocorrelation can, for instance, be eliminated by appropriately recognising the variable lags (provided that no certainty is gained as to the accuracy of the forecasts)[13]. Causality testing is based either on autoregressive distributed lag models (ARDLs), or vector autoregressive models (VARs). Proper specification of the variable lags is paramount and prerequisite in any of the applied models. Many surveys have proved that the results of Granger's causality test are sensitive to the selected lag lengths for variables under investigation[14]. Despite numerous analysis conducted as early as in the 1990s[15], discussion on the empirical problems entailed in causality verification continues to keep a prominent position in the professional literature.

2. Causality and Co-integration vs. Effective Forecasts

The dynamic forecasts for the last two quarters of 2005 were, in the case of stationary variables, generated based on two-equation VAR models where the optimal lag orders were identified before proceeding to the Granger causality analysis.

For the series which undergo the seasonal adjustment procedure, the selection of the VAR model, the causality test, and the generation of the dynamic forecasts is based on the adjusted series. Since the quarterly series of interest are characterised by deterministic or stochastic seasonality[16], in order to attain comparability of the relative errors for the original and adjusted series we cor-

[11] See Eichler (2007), Atukeren (2005).
[12] See Pesaran, Pesaran (1997).
[13] Ibidem.
[14] See Atukeren (2005).
[15] See Charemza, Deadman (1997).
[16] See Blangiewicz, Strzała (2006).

rected the forecasts with the use of the seasonal effects estimated for the respective quarters of year 2004.

In the evaluation of the usefulness of qualitative indicators for forecasting the stationary variables (I(0)) we use the relative forecast error and deem the projection acceptable, if the error does not exceed 5 % for the level of predicted category, and 10 % for the rate of growth. When considering the non-stationary (I(1)) variable forecasts, we compare the relative error in the generated forecasts with the error of the naïve projection.

In case of the I(1) variables the estimation of the co-integrated VAR model and determination of the number of the co-integrating vectors constitute an important stage in the procedure.

When analysing[17] the test results for the number of co-integrating vectors and the Granger causality we noticed no co-integration in 12 original series and 7 adjusted series out of 74 analysed pairs (37 original series pairs, and the same number of adjusted series pairs). In the case of the remaining 55 pairs we discovered the presence of 1 co-integrating vector, which means that the tested variables are long-term related and at the same time there exists the Granger causality relation between them[18]. Identification of the co-integrating relationship implies the presence of at least one Granger causality relation. This enables interpretation of the causality test results, however does not imply that the business tendency indicator is the Granger-type cause of the occurring macroeconomic category identified. The Granger causality relation may run from the qualitative variable to the quantitative tendency indicator.

A characteristic example can be found in the following pairs: PPI[19] $\Rightarrow$ PPIB, and PPI $\Rightarrow$ PPIBPP, which are co-integrated, and as such, following Granger's interpretation, enter the causality relationship. If we adopt the Granger causality test indications as the guideline, the co-integrating vector should be normalized with respect to the PPI. In other words, the past values of the quantitative variables (PPIB, PPIBPP) will improve the PPI forecasts, and not vice versa.

Whenever the presence of one co-integrating vector was found, it was decided to build the forecasts for 2005Q3 – 2005Q4 based on the vector error correction model (VAR-ECM).

Because the causality test results are not binding for variables showing no long-term stationarity, we did not rid further analysis of the variable pairs found both non-related in the Granger sense and not co-integrated. Nor, did we eliminate the co-integrated variable pairs where the causality test results indicated that the qualitative indicator was not the Granger cause of the specific macro-

[17] Table comprising the detailed results are available upon request

[18] See Granger (1988), Mehra (1994).

[19] PPI – expected selling prices, PPIBP –chain index of producer prices in industry, PPIBPP – chain index of producer prices in manufacturing.

economic category (23 pairs: 2 among the original series, and 21 among the seasonally adjusted series). When summing up the quantitative causality and co-integration test results we noted that 30 out of 74 pairs yielded „promising" results in that the variables were co-integrated and the qualitative indicator could be deemed the Granger cause of the identified macroeconomic variable.

Whenever no co-integration was found, the decision was made to generate forecasts based on the two-equation VAR model for I(1) variables, irrespective of the indications concluded from the causality test. Obviously, in such a case it is not only possible, but even recommended to adopt another approach, namely that of transforming the variables to the first differences and building the projections on the basis of the stationary VAR model. The approach was not adopted, however, because the qualitative business tendency indicators are, in their very definition, the variables of the incremental nature, since they were established as the net balances of the positive and negative responses, and are moreover weighted in the aggregation process. In any case, they are not titter values and evade direct interpretation. In connection with clear seasonality of the deterministic or stochastic nature, concluding only becomes possible when comparing the indicator with its value from the same period in the previous year or years. From the point of view of the interpretative potential of the projections built for the discussed macroeconomic categories, it was concluded there was no sense to proceed to the increments of such variables as the dLINW (logarithmic increment of investments), dLPRZSP, or dLPRZSPP (logarithmic increments of revenues from sold production in industry, and manufacturing, respectively), as this would translate to forecasting an increment of growth rate of the categories.

When analyzing the forecasts relative errors and assuming that the lesser the relative error, the higher projection quality is testified, we observed the following regularities:

- In most cases the forecasts relative errors arrived at using the VAR-ECM or VAR models are lower than those occurring in the naive projections. In 5 out of the 18 considered macro-categories the employed approach failed to generate forecasts whose error would be lower than the same error in the naïve projections. For WFBP (the gross profit in industry) the relative error in the naive projection for the category level, established based on an unadjusted series, is more than 5 times lower; for NALPRZ (short-term liabilities of enterprises in industry) it is almost twice lower, and for NALPP (short-term liabilities of enterprises in manufacturing) 25 % lower,
- The relative errors for adjusted variables are lesser than for non-adjusted series;
- The relative errors for the projected category levels are predominantly twice lower than the relative errors in the growth rate projections;

- The highest relative errors rendering the generated projections unacceptable are found in such categories as short-term liabilities of enterprises in industry (NALPRZ), and in manufacturing (NALPP), in the employment in industry (ZP) and in the manufacturing (ZPP);
- The lowest relative errors are found for such macro-categories as the Gross Domestic Product (PKB), domestic demand (POPKR), gross value added in the national economy (GVA) and in the industry (GVAP) where the time-series derive from the National Accounts and are expressed in fixed prices.

When forecasting the levels of such macro-categories as the gross domestic product (PKB), domestic demand (POPKR), gross value added in national economy (GVA), and the gross value added in industry (GVAP), the lowest relative errors were attained when the proposed procedure was performed on seasonally adjusted series. *T*he relative errors in the best projections based on such series (corrected with estimated seasonal effects) over the projected period are several to several-score times lower than the respective relative errors in the projections based on the original series. For instance, for the PKB level the relative error of the best projection achieved using the adjusted series was 0.1%, while the lowest error for the original series stood at 1.3%. For the domestic demand (POPKR) the same errors were established at 0.1% and 3.3%, respectively.

When analyzing the forecasted levels of the gross value added in the national economy (GVA) it was found that the relative error of the best forecast obtained for adjusted series was 6 times lower; for the gross value added in industry (GVAP) the error was 7 times lower. As for the other macro-categories, the relative errors in the projections based on adjusted series are most frequently only marginally lower or close to the respective relative errors found in the projections obtained with the use of the original series.

Noteworthy, all projections generated for the macro-category levels meet the acceptability criterion. On the contrary, most growth rate projections for the macro-categories, based on the original series do not meet the assumed acceptability margin (relative error of 10 %). Only three growth-rate forecasts fell within the acceptability range.

The picture of the admissibility issue looks different for the forecasts generated with the use of the adjusted series. In the growth rate group we arrived at 15 projections whose relative errors did not exceed the 10 % threshold.

To assess the usefulness of individual model types (VAR-I(0), VAR-I(1), VAR-ECM) one needs to note that the best forecasts in accordance with the adopted criterion were mostly obtained based on the vector error correction models (VAR-ECM) – 4 categories, i.e. PKB, POPKR, GVA, and GVAP. In case of the other two financial categories – the gross profit in industry (WFBP) and in the manufacturing (WFBPP) – the best forecasts were generated based on the VAR-I(1) models.

As concerns the growth-rate forecasts in 6 out of 18 macro-categories, where the projections passed the acceptability threshold, the most accurate forecasts were obtained based on the VAR models (4 categories); in the two other cases this was achieved based on the stationary vector autoregressive model (VAR-I(0)).

Testing Granger causality and the significance of the correlation coefficients is another issue worth mentioning in the context of the effectiveness of the proposed procedure. Here, the best forecasts in terms of the relative errors are found for both the Granger causality and non-causality. For instance, the 'best' forecast of the gross domestic product (PKB) was obtained based on the VAR-ECM model against the ZAMZ indicator (expected foreign order books), where the hypothesis claiming Granger non-causality was not rejected. Similarly, for the level and growth rate in the gross value added in the national economy (GVA) the best forecasts based on adjusted series were obtained using the VAR-ECM models and qualitative indicators, for which the hypothesis claiming Granger non-causality was not rejected. Similar coincidences are also found in several other cases, for instance for such stationary variables as the index of sold production in industry (IPPB) or the export growth rate (EKSPB), and for the non-stationary variables of: the index of producer prices in industry (PPIB) and the same index for the manufacturing (PPIBPP).

To conclude about the usefulness of the proposed econometric procedure from the point of view of its effectiveness understood as the relationship between the work load and the effects obtained, and especially taking into account the results of the causality tests, co-integration analyses, and the quality of the projections generated, one can propose a certain modification of the procedure. Considering the observations described above we propose to improve the effectiveness of the forecasting procedure by modifying it so as to omit the stage of establishing the significance of the correlation coefficients and testing Granger's causality, and narrow down the analysis to seasonally adjusted series (stage II).

Thus, the modified stages in the proposed procedure are as follows:

I. Log transformation of the macroeconomic series.

II. Seasonal adjustment of the series.

III. Analysis of the stochastic structure of the time-series.

IV. Generation of dynamic projections for stationary variables (I(0)) based on the stationary VAR-I(0) model

V. Generation of dynamic projections for I(1) variables based on the VAR-ECM model whenever one cointegrating vector is found, or based on the VAR-I(1) model when no cointegration is assessed.

VI. Evaluation of the relative error in the ex-post forecasts, plus final assessment of the projection quality.

3. Conclusions

The employed forecasting procedure enables identification of the qualitative indicators whose use in the building of short-term projections allows for arriving at acceptable forecasts. The above applies in particular to the forecasted levels of such macro-categories as the PKB, POPKR, and GVA, built based on seasonally adjusted series. Since most qualitative indicators of the business tendency surveys are non-stationary in nature, and the rejection of the hypothesis of Granger non-causality is frequently accompanied with no cointegration, we proposed leaving out the causality test stage and limiting the stage to testing co-integration of the non-stationary variables. Since the vector error correction model does not always prove to be the "best", we suggest introducing the stage of the ECM significance test. It should, however, be remembered that it is necessary to update systematically the applied set of qualitative indicators on a current basis. The latter stems from the shifts in the significance of individual indicators observed in the past, both in terms of the strength of the relationship, and the significance of the correlation, both obviously identified for variables at the same level of integration.

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