

CAUSES AND CHARACTERISTICS OF BUSINESS CYCLE IN LITHUANIA: A STRUCTURAL VAR APPROACH

Aurelija Proškutė*

Vilnius University, Lithuania

Abstract. We investigate the structural disturbances underlying the business cycle in Lithuania in the bivariate time series framework. In the structural VAR model constructed productivity, hours of work and output fluctuations over the business cycle are composed of technology and non-technology shocks. We find that a technology shock has a persistent positive effect on all three variables. Non-technology disturbance has a long-term impact on working hours and output, but it has a negligible short-run effect on productivity.

Differently from Gali (1999), the study has revealed no significant correlation between productivity and working hours under the effects of technology shocks on Lithuanian data. In contrast with the results of developed countries, non-technology shocks result in a significant negative correlation between the working hours and labour productivity in Lithuania.

Historical decomposition of output, productivity and working hours series allows distinguishing four different episodes of Lithuanian economy during the analysed timeline. In 1999, negative technology shocks played the biggest role in pushing the output down. During the period 2001–2004, the real GDP growth was supported by productivity increase due to technology shocks; in 2005–2008, non-technology shocks and the higher working hours were fuelling output growth together with a positive impact of the technology shock on productivity growth. Finally, 2008–2011 is the period of negative technology and non-technology shocks.

Key words: business cycle, structural VAR, technology shock, productivity, Lithuanian economy

Introduction

During the period under analysis (from 1998 to 2011) Lithuania experienced two economic crises. The output dropped significantly during the Russian crisis in 1998–1999 and the global financial crisis of 2008–2011. Swings of economy always draw a particular attention of researchers and policy makers to their possible causes. It is important to understand where these movements come from, what their long-term and short-term effects on the economy are, as well as what policy reaction (if any) should be employed in smoothing these fluctuations over time. An additional initiative to explore business cycle characteristics in Lithuania is the scarcity of the related research. For a number of years, an objective reason has been the short timeline of macroeconomic series, which could complicate the empirical research and put doubts on the validity of

* Corresponding author.

*Faculty of Economics, Vilnius University, Saulėtekio Ave. 9, LT-10222, Vilnius, Lithuania;
e-mail: auretaure@yahoo.com

the assumptions. “[When] the parameters of the model are largely determined by the statistical estimation given severe data problems (short time series, errors in data, etc.), [the estimates] are subject to great uncertainty” (Vetlov, 2004: 27). However, with each subsequent year the datasets expand, thus opening new opportunities in exploring the dynamics of Lithuanian economy more robustly. Finally, being an economy in transition, the Lithuanian business cycle may have additional features or hold specific properties different from the evidence of developed economies. Thus, it is of particular interest to compare the findings of developed economies with the results for developing countries (Lithuania).

Understanding the causes of the business cycle and their effects on macroeconomic processes is an important issue in economics; it is one of the central topics of macroeconomic modelling worldwide. However, it is not an easy issue; it requires a detailed analysis and sophisticated research techniques to be explored thoroughly. This article presents a simple bivariate model as the first step towards a better understanding of the underlying reasons of the past economic events in Lithuania. The empirical analysis sheds some light on the dynamics of the main macroeconomic variables and presents a historical decomposition of the series into structural technology and non-technology components. It also checks the empirical validity of theoretical assumptions concerning labour productivity and labour supply relationship used in more complex macroeconomic models.

The purpose of this study was to expand the current knowledge of the forces forming the business cycle in Lithuania and macroeconomic variables (output, productivity and working hours) movements in response to these structural shocks. The objectives of the study were:

- to use a simple structural VAR framework in the analysis of structural shocks;
- to explore the long-run and short-run responses of productivity, working hours and output to technology and non-technology disturbances;
- to decompose the historical macroeconomic series into the two structural components;
- to analyse episodes of economic growth and decline and the prevalence of technology / non-technology components during them;
- to estimate conditional correlations between productivity and hours worked under the effect of technology and non-technology shocks;
- to compare the findings with theoretical predictions of the models.

The paper is structured as follows. The first section presents an overview of a similar analysis and results for other countries as well as a short discussion of the existing macroeconomic shock analysis in Lithuania. In Section II, details of the theoretical economic model and the empirical model techniques used to evaluate the model are explained. Section III continues with the data descriptions, results of employing the

model are discussed in Section IV. Conclusions and possible extensions are presented in Section V.

I. Literature overview

This paper follows a seminal work of Gali (1999) who builds a bivariate structural vector autoregression model of labour productivity and working hours to explore the responses of these variables to technology and non-technology shocks. Among the most important findings of the model for G7 economies is the evidence that hours exhibit a permanent negative response to a positive technology shock and a conclusion that working hours correlate negatively with labour productivity under effects of technology shocks and positively under non-technology shocks. These striking results contradicting the real business cycle theory assumptions (Kydland, Prescott, 1982) gave an impulse to an additional investigation of the topic.

There are a number of researchers who confirm the findings of Gali (1999). Shea (1998) proposes another method for measuring technology innovations and finds that technology shocks in the US industries produce permanent negative effects on the labour supply despite their positive short-run effects. Basu et al. (2004) estimates the model for the US with a “true measure” of aggregate technology change calculated on a disaggregated technology change on a sector level of 29 US industries and then aggregated up. The study confirms the results of Gali (1999). Another piece of evidence is presented in Gali (2004); the author finds a very limited role of exogenous technology shocks in business cycle movements for the European Monetary Union.

Some other authors detect differing patterns of the data once the model is estimated on subsamples of the series. Among those is the survey of Francis and Ramey (2006) who proceed with the construction of an identical model as the one of Gali (1999) on a different dataset; annual US data extending back to the late 19th century are used in calculations. They estimate the impulse-response functions of the series on two subsamples and conclude that the effects of technology shocks on output have decreased in the post-war period. They also show that negative response of hours to productivity shocks appears in 1949–2002 inverting the relationship estimated on 1892-1940 data. In a study on the reasons of the Great Moderation, Gali and Gambetti (2006) re-estimate the model with US data on different horizons and find that after 1984 the correlation of hours with labour productivity has experienced a remarkable decline, shifting from values close to zero in the pre-84 period to large negative values after 1984; among other numerous results, they come up to a conclusion that the negative response of hours to productivity improvements has become smaller over time.

Finally, some economists find a contradicting evidence to the conclusions of Gali (1999). Christiano et al. (2003) provide empirical evidence that a positive technology shock drives working hours up, but not down. This is achieved using a slightly different

variable for labour supply, namely hours working per capita. The authors defend the assumptions of real business cycle theory and argue that no new versions of the model are required. Dupaigne and Feve (2009) repeat the calculations for G7 countries and find that, under alternative SVAR evaluations, employment increases significantly in every G7 country once a world-permanent productivity shock is introduced.

A variety of findings and contradicting conclusions for developed economies give no information on how technology and non-technology components affect the dynamics of labour productivity, working hours and output in Lithuania or in other developing economies. The Gali (1999) model has never been tested on Lithuanian time series, thus the findings of this study, related to the responses of productivity and working hours to shocks or conditional correlations have no counterpart surveys and comparable results for Lithuania.

When answering the question concerning the driving forces of the business cycle in Lithuania, data of this article are partially comparable with the results of Karpavičius (2008) who constructs a dynamic stochastic general equilibrium (DSGE) model for Lithuania to reveal the shocks that are prevail in Lithuania. The effects of 14 different shocks are analysed; the answer is that the variance of output is mainly determined by non-technology shocks (among which external demand and interest rate shocks would be most important) and domestic technology shocks; the variance decomposition indicates 85% and 15%, respectively. The variance of employment, which is a proxy to the variable of working hours used in our model, appears to be mainly driven by external demand, global interest rate shocks and domestic fiscal policy disturbances. According to this model, all non-technology shocks explain about 91% of variation in employment while domestic technology shocks account for about 9%.

The analysis of non-technology shocks explored in this paper could be complemented with the findings by Ramanauskas (2011) on the causes of the recent boom and bust in Lithuania. The author concentrates his analysis on four shocks which are believed to have the biggest influence on recent macroeconomic effects in Lithuania. He finds that foreign demand was an important output determinant during the boom and slowdown periods. Among the local factors, government's discretionary fiscal policies and easy credit conditions are seen as potential contributors to the economic overheating and the ensuing crisis. All these factors combined together would be comparable to a non-technology shock estimated in our model.

II. Economic and empirical model

The economic model underlying the empirical estimations could be a real business cycle model with optimising households, perfectly competitive firms in the market or a simple general equilibrium model with money, monopolistic competition, sticky prices and variable labour effort suggested by Gali (1999). Technology and non-technology shocks

are the two driving forces in both models. The latter one stands for all disturbances that do not have permanent effects on labour productivity; government spending, monetary policy, preference and other shocks are a few examples of what a non-technology shock might be. Technology and non-technology shocks are allowed to have permanent or transitory effects on all variables in the system, with the only exception of the non-permanent effect of a non-technology shock on productivity.

One of the key differences between the two theoretical models is the way they explain a negative (or close-to-zero) correlation between working hours and labour productivity observed in actual economic data of many countries. A real business cycle model assumes that under technology shocks the productivity and working hours correlate positively and that non-technology shocks are the ones that shift labour supply up, producing a negative co-movement between the two. On the contrary, a model with sticky prices and monopolistic competition predicts a negative co-movement between hours and productivity under technology disturbances and a positive correlation between productivity and working hours under effects of non-technology shocks (more details of the economic model are presented in Gali (1999: 251–255)).

To resolve the debate of the model better suited to describe actual economies, empirical calculations were carried out to check the relevance of the assumptions.

The econometric model used to estimate the theoretical model is specified as follows:

$$B \begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} = \Gamma_0 + \Gamma_1 \begin{bmatrix} x_{1t-1} \\ x_{2t-1} \end{bmatrix} + \Gamma_2 \begin{bmatrix} x_{1t-2} \\ x_{2t-2} \end{bmatrix} + \dots + \Gamma_p \begin{bmatrix} x_{1t-p} \\ x_{2t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix},$$

here x_{1t} and x_{2t} are stationary transformations of the macroeconomic variables of interest, ε_{1t} and ε_{2t} are structural shocks, and B , Γ_0 , Γ_1 , Γ_2 are (2×2) matrices of the structural coefficients.

The estimation of the system requires its pre-multiplication by B^{-1} :

$$\begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} = B^{-1}\Gamma_0 + B^{-1}\Gamma_1 \begin{bmatrix} x_{1t-1} \\ x_{2t-1} \end{bmatrix} + B^{-1}\Gamma_2 \begin{bmatrix} x_{1t-2} \\ x_{2t-2} \end{bmatrix} + \dots + B^{-1}\Gamma_p \begin{bmatrix} x_{1t-p} \\ x_{2t-p} \end{bmatrix} + B^{-1} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}.$$

Therefore, only reduced-form VAR coefficients of the model can be estimated:

$$\begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} = A_0 + A_1 \begin{bmatrix} x_{1t-1} \\ x_{2t-1} \end{bmatrix} + A_2 \begin{bmatrix} x_{1t-2} \\ x_{2t-2} \end{bmatrix} + \dots + A_p \begin{bmatrix} x_{1t-p} \\ x_{2t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix},$$

where

$$A_0 = B^{-1}\Gamma_0, \quad A_1 = B^{-1}\Gamma_1, \dots, A_p = B^{-1}\Gamma_p \quad \text{and} \quad \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = B^{-1} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}.$$

An important step in structural VAR recovery is the estimation of structural shocks $\begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$ from the calculated reduced-form VAR residuals $\begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix}$. With two endogenous variables (and two structural shocks), the estimation of structural coefficients of the system requires one additional identifying assumption.

The idea of how to solve the issue was raised by Blanchard and Quah (1989) in their paper on supply and demand shock identification within the GDP and unemployment series. They suggested using the economic theory to impose additional restrictions on the long-run effects of shocks onto economic variables. The authors made the assumption of no long-run effects of demand shocks on output, and thus the system could be identified. Similarly, in our model of productivity and working hours, the structural errors (technology and non-technology components) are estimated with the help of an additional restriction of no long-run effects of non-technology shocks on productivity.

Once the model is estimated, most of the results are taken from rewriting it in the distributed-lag form:

$$\begin{aligned} \begin{bmatrix} \Delta z_{1t} \\ \Delta n_{2t} \end{bmatrix} &= C_0 + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} + C_1 \begin{bmatrix} \varepsilon_{1t-1} \\ \varepsilon_{2t-1} \end{bmatrix} + C_2 \begin{bmatrix} \varepsilon_{1t-2} \\ \varepsilon_{2t-2} \end{bmatrix} + C_3 \begin{bmatrix} \varepsilon_{1t-3} \\ \varepsilon_{2t-3} \end{bmatrix} + \dots = \\ &= C_0 + \begin{bmatrix} C_{11}(L) & C_{12}(L) \\ C_{21}(L) & C_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{1t-1} \\ \varepsilon_{2t-1} \end{bmatrix}. \end{aligned}$$

In this system, C_k measures the k -th period response of the endogenous variables to a unit structural disturbance.

III. Data description

The bivariate model is estimated from data on labour productivity and working hours. Productivity is calculated as a ratio of real GDP and the number of working hours in the economy. All the variables used in calculations are extracted from Lithuanian statistical department databases on a quarterly basis. Detailed variable names and the data sources can be found in Appendix A. The model is estimated with seasonally adjusted series.

Before estimating the output of the bivariate model, a descriptive analysis of the three variables of our attention – productivity, working hours and real GDP – is carried out. Analysing their dynamics over the period 1998 Q1 – 2011 Q3, in Fig. 1–3 several features stand out. The series of chain-linked volume of GDP, representing the dynamics of output, are split into trend and cyclical components by employing the Hodrick–Prescott filter. It shows the two well-known crisis periods in Lithuania (1998–1999 and 2008–2011), also confirmed by other methods and techniques (Kučinskas, 2011).

Productivity (Fig. 3) exhibits downward movements during the crises, connected with a smooth growth period inbetween. The time series of the number of working hours has three distinctive stages: a drop to lower levels in 1999–2004, an increase in the working hours in 2005–2008, and a downward shift in 2008–2011. In contrast to the clearly seen

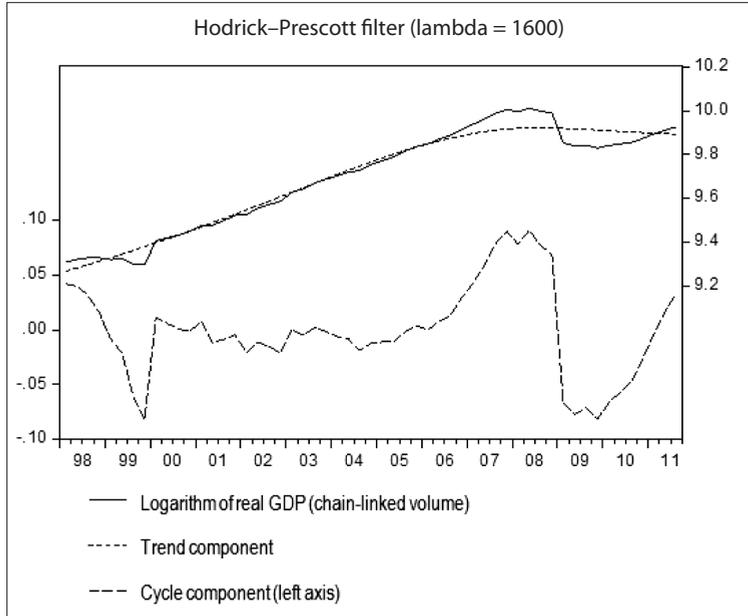


FIG. 1. Decomposition of chained-volume GDP of Lithuania into trend and cyclical components using HP filter, 1998 Q1 – 2011 Q3

Source: Statistics Lithuania and author's calculations.

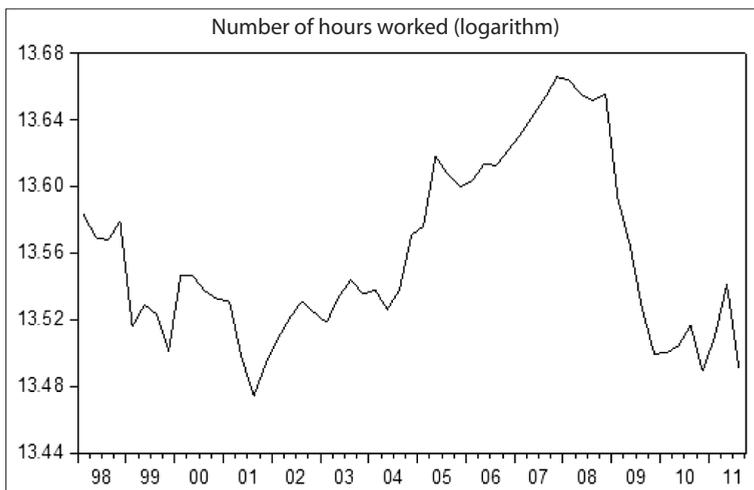


FIG. 2. Dynamics of hours worked in Lithuania over the period 1998 Q1 – 2011 Q3

Source: Statistics Lithuania.

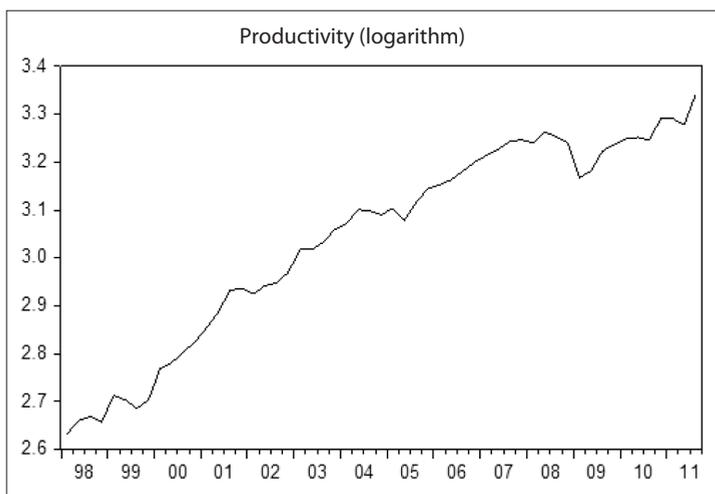


FIG. 3. Dynamics of labour productivity in Lithuania over the period 1998 Q1 – 2011 Q3
Source: Statistics Lithuania, author's calculations.

TABLE 1. Descriptive statistics of selected macroeconomic variables, 1998 Q1 – 2011 Q3 (p-values in brackets)

	Growth rate of hours worked	Growth rate of productivity	Growth rate of real GDP
Mean	-0.17%	1.31%	1.14%
Median	0.01%	1.38%	1.52%
Maximum	4.57%	6.50%	11.07%
Minimum	-6.32%	-7.33%	-13.60%
Std. Dev.	2.21 p.p.	2.35 p.p.	2.76 p.p.
Correlations:			
Growth rate of productivity	-0.269 (0.0494)	1	
Growth rate of real GDP	0.572 (0.0000)	0.636 (0.0000)	1

Source: Author's calculations.

productivity and output co-movements along the economic cycle, the level of hours does not seem to show a clear response to business cycles (difference in the episodes 1998, 2005 and 2009).

The descriptive statistics of growth rates of the three variables in Table 1 shows the real GDP to have the highest volatility among the three series, while the growth rates of working hours and productivity have lower standard deviations (2.21 and 2.35 percentage-points, respectively). The minimum and maximum growth rate ranges of output are almost double the ones of working hours and productivity. The co-movements between productivity and output, observed on the level of data, also show the same

pattern when expressed in growth rates of the two variables: the unconditional correlation between the two is 0.636. A small negative correlation (-0.269) is estimated between the growth rates of productivity and hours.

To construct a vector autoregression model, both endogenous variables were checked for stationarity and cointegration. The augmented Dickey–Fuller test results can be found in Appendix B. They indicate that with a 5% probability the hypothesis of a unit root in both series cannot be rejected. The Johansen cointegration test finds no cointegrating relations between the two series at the 5% significance level. As a result, both variables are taken in differenced logarithm form to eliminate the stochastic trend from each series, and the bivariate system is estimated on the growth rate of productivity and the growth rate of the number of working hours.

IV. Results

The estimation of the bivariate model has been carried out for the period from 1998 Q1 to 2011 Q3 considering this a more reliable statistical data collection period. The calculations were repeated for the extended period from 1995 Q1 to 2011 Q3 without major changes in the results. To check the robustness of the results, an alternative set of variables was considered. Real GDP per employee was taken as a proxy for labour productivity, and the number of employees was selected to illustrate the labour supply dynamics. Again, the results showed the same trends and patterns; as a result, we chose to illustrate the results of the original pair of variables, primarily used in Gali (1999).

The distributed-lag form of the system gives the first result of the estimated model. Analysis of the impulse-response of the technology and non-technology components on the two variables of the system is presented in Fig. 4. It shows the reaction of the analysed variables to each structural shock of the size of 1-standard deviation.

Impulse-response functions show that a positive technology shock has an immediate positive effect on productivity, which remains at the same higher level in the long run. The long-term effect of 1-standard-deviation positive technology shock equals to an approximately 2.5% increase in productivity. On the contrary, the immediate reaction of working hours to a technology shock is small but negative in the first period. However, starting with the second quarter, the number of hours worked goes up significantly until it reaches a 2% increase in the long run. As a result of the productivity and working hour movements, the permanent increase in real GDP from a positive technology shock is approximately 4.5% in the long-run.

The non-technology shock does not have a long-run effect on productivity as the identifying assumption of the model and economic theory show; however, its short-run effect is also negligible. The response of working hours to a positive non-technology disturbance is immediate and positive: the labour supply rises by 2%; as a result, the productivity drops by 0.3% in the first two quarters. We might consider this a ‘congestion’ or decreasing economies of scale effect when an increased labour input produces a

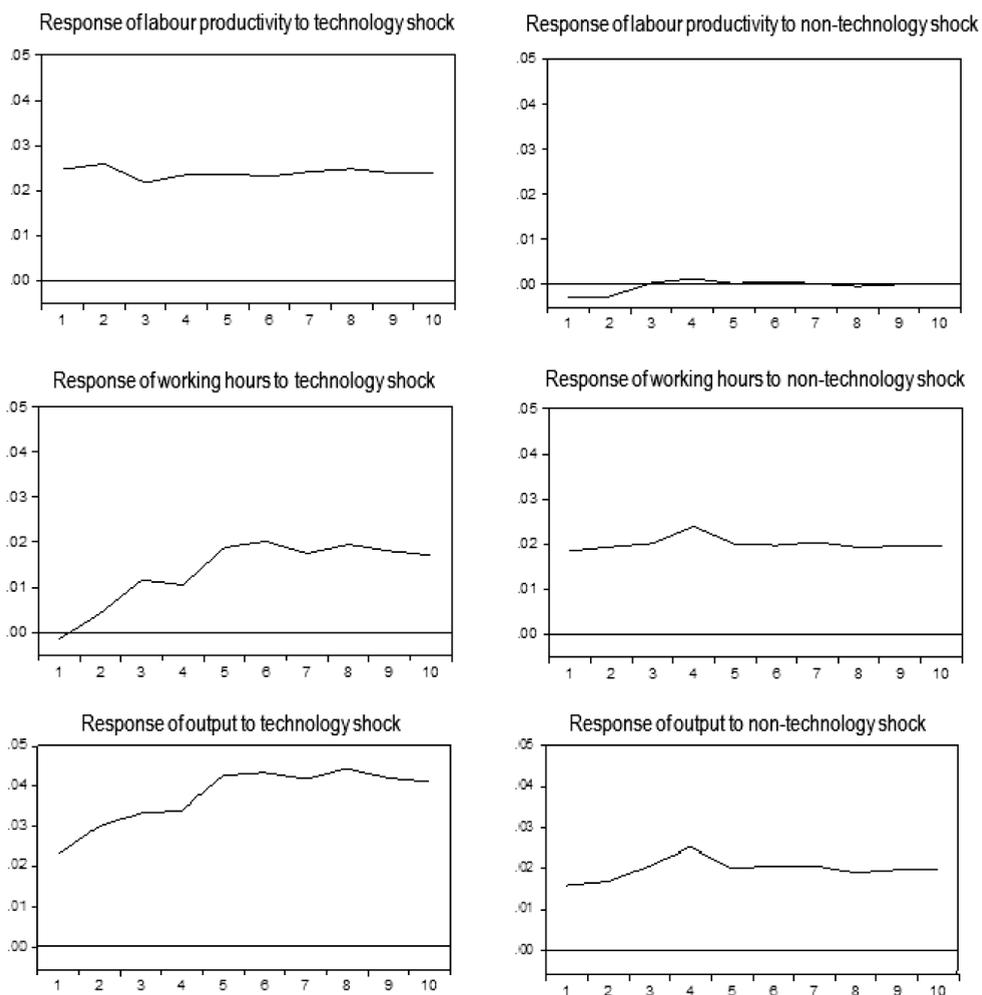


FIG. 4. Impulse-responses of labour productivity, working hours and output to technology and non-technology shocks of 1-standard deviation

Source: Author's calculations.

smaller output per working hour. In the two subsequent quarters, the number of hours rises immediately and reaches a peak in one year with a 2.5 % increase from the initial level. Labour productivity also starts rising; a small positive effect is seen in a year after the shock. Finally, in two years from the initial movements, a new state of the economy is reached: productivity comes back to its original level, and the number of hours worked stays at an approximately 2% higher level than before the non-technology shock. A combination of the effects on both variables also gives a rise to the real GDP by approximately 2% in the long-run.

The shapes of impulse-response functions of the variables in Lithuania resemble the ones of Canada, estimated in Gali (1999), although permanent changes of the variables

are larger for Lithuania. This can be attributed to the economy-in-transition effect when all the macroeconomic variables are rapidly catching up with the ones of more developed economies, thus exhibiting a faster growth, larger variances and stronger responses to disturbances of the economy.

The estimation of the SVAR model on the Lithuanian data allows us to analyse retrospectively the contributions of technology and non-technology disturbances into the series of productivity, working hours and output. The historical decomposition of productivity, working hours and output fluctuations into technology and non-technology components over the period 1999 Q1 – 2011 Q3 in Lithuania are presented in Fig. 5.

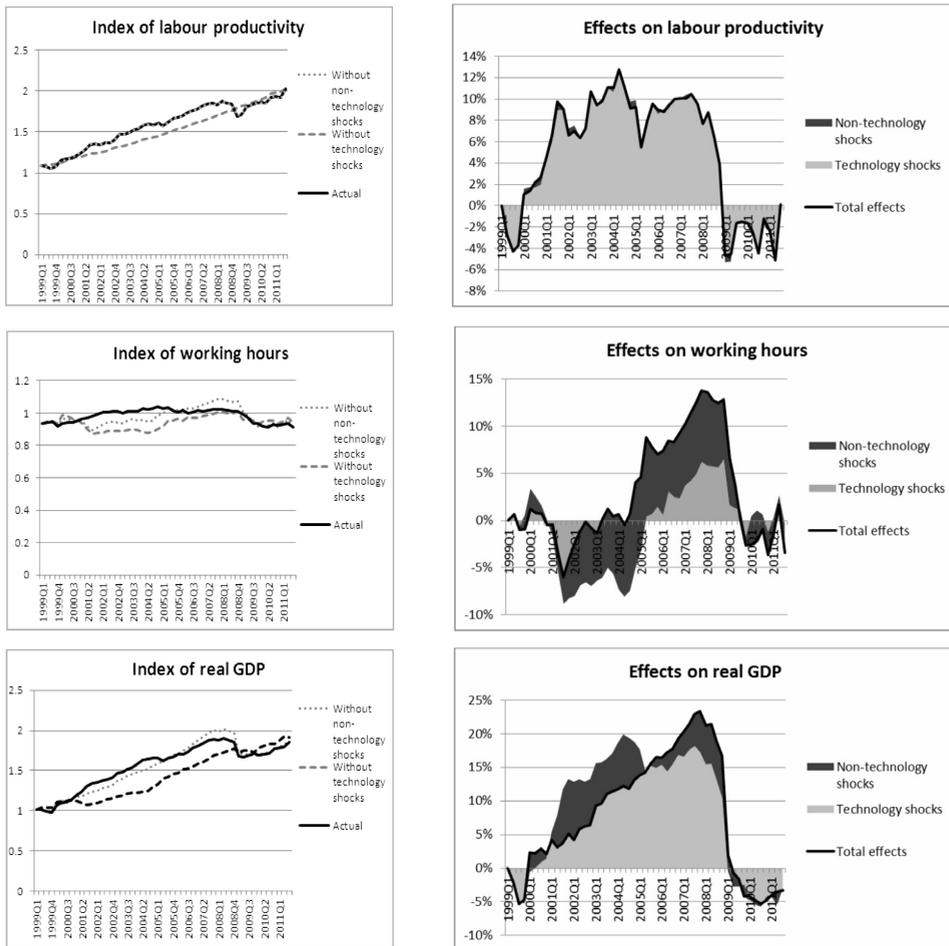


FIG. 5. Effects of technology and non-technology components on productivity, hours of work and output fluctuations in Lithuania, 1999 Q1 – 2011 Q3 (panels on the left show the dynamics of each variable absent effects of each of the shocks; the panels on the right show stacked net effects of the shocks on the three variables)

Source: Author's calculations.

In Fig. 5 we can see that during the entire period under analysis, technology disturbances were more important in driving the productivity compared to non-technology shocks. The latter played a negligible role in productivity movements, even in the short run. In contrast, working hours were affected by both technology and non-technology disturbances during the period.

The decomposition of output fluctuations into technology and non-technology components has revealed four different episodes of underlying economic movements in Lithuania. In 1999, the real GDP was dampened by a negative technology shock and a small negative effect of non-technology disturbance. Throughout 2000–2004, positive technology shocks boosted the productivity growth, but their effects on real GDP were dampened by negative technology shock effects and a negative non-technology shock, reducing the number of working hours considerably. Nevertheless, the strong technology advancements allowed the real GDP to increase considerably despite the decreasing working hours caused by negative effects of technology and non-technology disturbances. 2005–2008 was the episode of a strong GDP growth supported by positive technology and non-technology shocks and their large positive inputs to productivity and working hours, respectively. Finally, the 2008–2011 period of reversed tendencies with negative non-technology effects on working hours and negative technology shock dominating productivity developments produced a drop in the real GDP of Lithuanian economy.

These results are partially in line with the findings of other authors. In a calibrated DSGE model for Lithuania, Karpavičius (2008) finds a smaller impact of technology shocks on output and employment series; however, the estimates of an impulse-response path of real GDP to technology shock are quite similar. These differences can be attributed to the differences coming from the model types as well as different time periods considered for estimations. Among the strongest causes of a recent boom of the Lithuanian economy (2005–2008), Ramanauskas (2011) finds a number of non-technology shocks responsible for economic overheating and the ensuing crisis in Lithuania: foreign demand, government's discretionary fiscal policies and easy credit conditions are seen as potential factors for it. These results complement the analysis of this paper in analysing the non-technology shocks in more detail.

The disaggregation of the macroeconomic series into technology and non-technology components allows us to calculate the conditional correlations of productivity and hours under each of the shocks. The analysis is important for understanding what model could better describe the macroeconomic processes in Lithuania and adding another piece of evidence into the long-lasting discussion of RBC and model with sticky wages and prices in explaining the business cycles. Table 2 reports the unconditional and conditional correlations of the growth rates of productivity and working hours. The calculations are illustrated in Fig. 6 which gives the scatter plots of the quarter-on-quarter growth rates of productivity and the number of hours.

TABLE 2. Correlation estimates of the growth rates of productivity and working hours, Lithuanian data 1998 Q1 – 2011 Q3 (p-values in brackets)

	Unconditional	Conditional on technology shock	Conditional on non-technology shock
Correlation estimates between growth rates of productivity and working hours	-0.268 (0.0494)	-0.18 (0.100)	-0.47 (0.000)

Source: Statistics Lithuania, author's calculations.

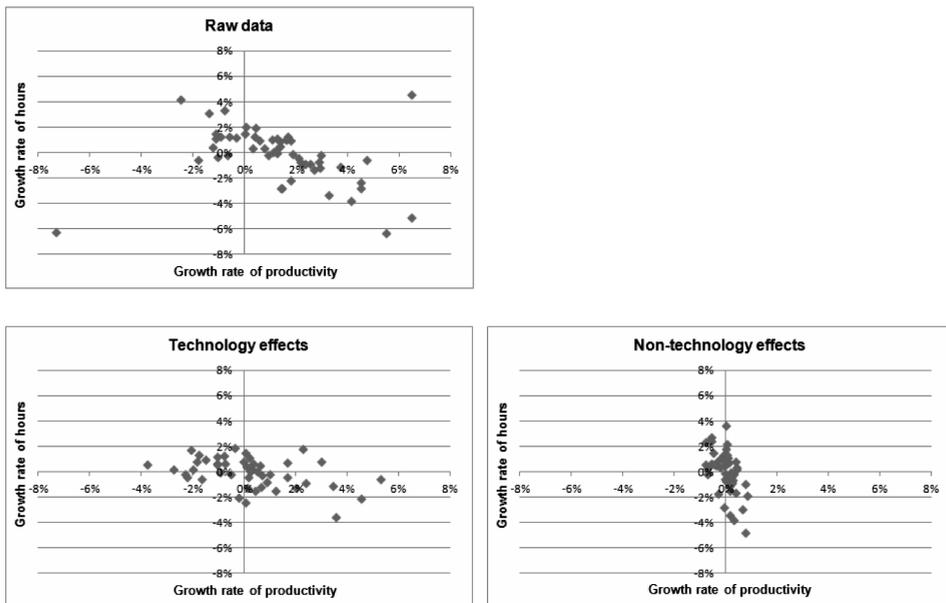


FIG. 6. Technology and non-technology components in the growth rates of productivity and the number of working hours, 1998 Q1 – 2011 Q3

Source: Author's calculations.

Table 2 and Fig. 6 show the results for Lithuania which are in contrast to the data of other countries. The unconditional correlation between labour productivity and working hours is weakly negative (and significant) for the period under analysis in Lithuania as is common for developing and developed economies globally. A difference shows up in comparing the conditional correlations: contrary to Gali (1999) findings for developed countries (except Japan), the non-technology effects of the two variables in Lithuania show a negative (and significant) correlation over the period 1998–2011. In contrast to the findings in G7 countries where technology components in both series exhibit strong negative correlations, technology effects in hours and productivity appear to have no significant co-movements in Lithuania. The results for Lithuania partially confirm

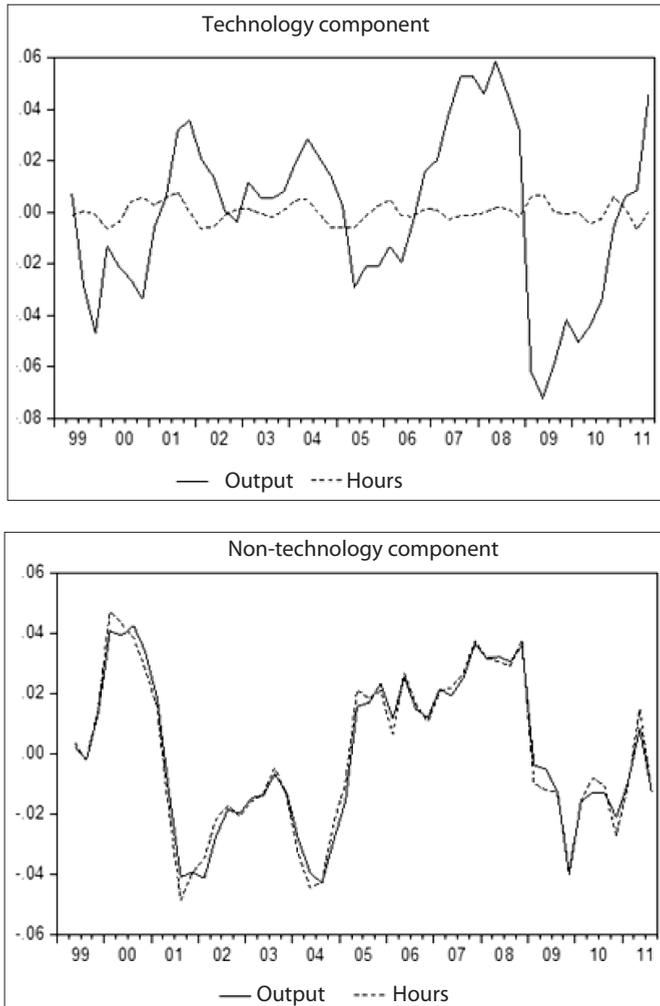


FIG. 7. Co-movements of the technology (left panel) and non-technology components (right panel) in output and working hours series at business cycle frequency (cyclical components after HP filtering of each series are taken), 1999 Q1 – 2011 Q3

Source: Author's calculations.

the assumptions of a real business cycle model in the which negative unconditional correlation is explained by the negative correlation effects arising from non-technology shocks. On the other hand, the results do not prove that under technology disturbances the productivity and working hours move together. Therefore, the question cannot be answered unambiguously and leaves room for the further investigation.

The answer of the theoretical model validity remains unclear while examining the last piece of evidence on the co-movements of real GDP and working hours at the business cycle frequency. For that task, technology and non-technology components in the Lithuanian real GDP and working hours series are de-trended with a HP filter to

observe only the cyclical component of each. Figure 7 presents the results. The results for Lithuania repeat the findings of Gali (1999): the correlation of technology components in real GDP and working hours shows a small positive but insignificant correlation, while the non-technology components in the two series have strong positive co-movement patterns (a strong positive and statistically significant correlation of 0.98) at a business cycle frequency.

V. Conclusions

This paper is one of the few attempts to analyse the business cycle in Lithuania. Two issues are analysed in the study. Firstly, we try to get a better understanding of the driving forces behind the business cycle in Lithuania. Secondly, we are interested to see how the results of the model for Lithuania match the findings of a similar survey for the developed economies.

To answer the questions, a bivariate structural VAR model for Lithuania has been constructed. The effects of technology and non-technology shocks on labour productivity, working hours and output are analysed employing this model.

The estimates of the model for Lithuania show that a positive technology shock has a positive long-term effect on productivity, hours and output. A positive non-technology disturbance has a small impact on labour productivity in the short run (no effects in the long run), contrary to an immediate positive and persistent reaction of working hours and output.

The retrospective analysis of the Lithuanian output series by decomposing it into structural components divides the entire timeline into four different episodes of macroeconomic development. 1999 was the year of a negative technology shock and small negative effects of the non-technology shock. During 2000–2004, technology shocks induced a strong productivity growth which was dampened by decreasing working hours due to negative non-technology shocks. Throughout 2005–2008, the Lithuanian economy was fuelled by technology shocks (to a smaller extent than the previous episode) and positive non-technology shocks boosting labour supply. The picture changed in 2008–2011 when negative technology and non-technology shocks pushed the Lithuanian output to a negative growth phase.

Among the new results which have not been estimated in Lithuania before are the conditional correlations of output and hours of work with technology and non-technology disturbances. The non-technology shocks have been found to generate a significant negative correlation between the growth rates of the number of hours and productivity, while the technology shocks do not produce statistically significant co-movements between hours and productivity. This result stands in a sharp contrast with the findings of Gali (1999) for the industrialized economies.

While examining the conditional co-movements of technology and non-technology components in labour productivity and working hours, a natural question of the choice of the underlying theoretical model arises. There has been a long debate among economists about the suitability of the real business cycle model vs the model with wage and price stickiness for explaining the real economic events, which is still continuing. Obviously, this simple research does not solve the dispute, but it adds another piece of evidence for further considerations. Conditional correlations do not confirm the need for a model with sticky prices and wages, suggested by Gali (1999) and supported by some other authors (Francis, Ramey, 2005). However, the additional results do not prove the correctness of the real business cycle model, either: absence of a significant correlation between productivity and hours, of clear co-movements between technology components in output and working hours at the business cycle frequency leave the question open for further research.

This study is an attempt to analyse the causes of business shocks in Lithuania and the effect of the shock propagation mechanism on the main macroeconomic variables. The model presented in this paper allows for the initial step into a deeper and more sophisticated analysis, thus it should be subject to amendments and additional theoretical considerations in the future. The possible extensions include suggestions to increase the dimensions of the model by including additional macroeconomic variables and to check the robustness of the results, applying the same model on sector data to check the stability of findings (Giannone, Reichlin, 2006) or including global productivity shocks (Dupaigne, Feve, 2009) which have changed some of the original Gali (1999) findings for developed economies.

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Appendix A. Sources of the variables used in calculations

TABLE 3. Sources and complete names of the variables used in calculations

Database	Full table name	Variable selected	Variable name used in the model	Period	Date of extraction
Economy and Finance (macro-economics)	Employment in domestic concept, hours worked by economic activity	Total hours worked, thousand hours	Working hours	1995 Q1 – 2011 Q3	December 2011
Economy and Finance (macro-economics)	Gross domestic product (GDP) by quarter	Chain-linked volume of GDP, LTL million	Output	1993 Q1 – 2011 Q3	December 2011
Population and Social Statistics	Labour force, employment and unemployment by age, place of residence, sex, quarter	Employed population, thousand	Number of employees	1998 Q2 – 2011 Q3	December 2011

Source: Statistics Lithuania, Database of Indicators, access through internet at: <http://db1.stat.gov.lt/stat-bank/SelectTable/omrade0.asp?SubjectCode=S3&PLanguage=1&ShowNews=OFF>

Appendix B. Augmented Dickey–Fuller test results

Null hypothesis: a variable has a unit root.

MacKinnon (1996) one-sided p-values are presented in the tables below.

TABLE 4. Unit root tests of working hours

	Ln, hours	Δ ln, hours
Constant	0.6291	0.0000
Trend and constant	0.9023	0.0000
None	0.4646	0.0000

Source: Author's calculations.

TABLE 5. Unit root tests of labour productivity

	Ln, productivity	Δ ln, productivity
Constant	0.5041	0.0000
Trend and constant	0.7363	0.0000
None	1.0000	0.0000

Source: Author's calculations.

TABLE 6. Unit root tests of output

	Ln, output	Δ ln, output
Constant	0.5328	0.0000
Trend and constant	0.9724	0.0000
None	0.9921	0.0000

Source: Author's calculations.