LATVIJAS BANKA

ISBN 9984–676–74–9

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THE BALTIC STATES AND EUROPE: COMMON FACTORS OF ECONOMIC ACTIVITY

3• 2008

WORKING PAPER

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CONTENTS

ABBREVIATIONS

CEE countries – Central and Eastern European countries
CIS – Commonwealth of Independent States
CSB – Central Statistical Bureau of Latvia
EEA – European Economic Area
EMU – Economic and Monetary Union
ERM II – Exchange Rate Mechanism II
EU – European Union
EU10 – countries which joined the EU on 1 May 2004
EU12 – countries which joined the EU on 1 May and 1 January 2007
EU15 – EU countries before 1 May 2004
Eurostat – Statistical Office of the European Communities
GDP – gross domestic product
GLS method – Generalised Least Squares Method
HICP – harmonised index of consumer prices
ML – maximum likelihood
NBER – National Bureau of Economic Research
NGP – national gross product
OCA – optimum currency area
OECD – Organisation for Economic Co-operation and Development
PCA – Principal Components Analysis
PFA – Principal Factors Analysis
ULS method – Unweighted Least Squares Method
US – United States of America

Country codes
AT – Austria
BE – Belgium
CY – Cyprus
CZ – Czech Republic
DE – Germany
DK – Denmark
EE – Estonia
ES – Spain
FI – Finland
FR – France
HU – Hungary
IT – Italy
JP – Japan
LT – Lithuania
LV – Latvia
MT – Malta
NL – Netherlands
PL – Poland
RU – Russia
SE – Sweden
SI – Slovenia
SK – Slovakia
UK – United Kingdom
US – United States of America

ABSTRACT

This paper aims at characterising fluctuations of economic activity that are common for the Baltic States, CEE countries, euro area countries and Russia. The real standardised GDP quarterly growth is chosen as an indicator of economic development of the countries. Three methods are employed: static factor analysis, dynamic factor model and dynamic correlation. Special attention is given to the analysis of Latvian economy.

The results of the study show that the Baltic economies are similar in economic development and share a common factor. After 2000, the real standardised GDP growth in the Baltic States became more correlated with the GDP growth of the main euro area countries indicating growing synchronisation of economic development between these country groups.

The role of the main final demand components (exports, consumption and investment) in explaining common fluctuations in the real standardised GDP growth in the Baltic States is evaluated by analysing common factors for each component and dynamic correlation between components for each country.

Keywords: *business cycle synchronisation, dynamic factor model, dynamic correlation.*

JEL classification: *E32, F20, C10*

The views expressed in this publication are those of the authors, who are employees of the Bank of Latvia Monetary Policy Department. The authors assume responsibility for any errors or omissions.

The authors would like to thank Konstantīns Beņkovskis (Bank of Latvia) for assistance in developing the dynamic correlation programme, and Zoja Razmusa, Uldis Rutkaste and Viktors Ajevskis (Bank of Latvia) for helpful comments and recommendations.

INTRODUCTION

Fluctuation of economic activity represents cyclical development of a country. The ability to assess the magnitude of cross-country co-movements in the economic activity of the Baltic States and to obtain a common development pattern with other countries of the EU, particularly the euro area, is of great importance, taking into account the EU objective to establish not only a common economic area but also a common monetary area. To enter the euro area, the new EU member states should meet the Maastricht criteria, which include successful participation in the ERM II for two consecutive years. The majority of the new EU member states (except Slovenia, which has already adopted the euro, Poland, the Czech Republic and Hungary) have already joined the ERM II.[1]

Participation in the EEA and the intention to join the monetary union increased the motivation of the new member states to achieve a high level synchronisation of economic activity with the euro area. In the case of synchronised economic fluctuations, the costs of possible counter-cyclical monetary policy are minimised[2], and it is in line with the theory of optimum currency area (OCA)[3].

This paper aims at characterising the fluctuations of economic activity that are common for the Baltic States, CEE countries represented by the Czech Republic, Hungary, Poland, Slovakia and Slovenia, the euro area countries represented by France, Germany and Italy, as well as the CIS represented by Russia. The real standardised GDP quarterly growth is chosen as an indicator of economic development of the countries.

The main questions to be answered within the current research are as follows:

– Do the Baltic States have a common factor in the real GDP growth?

– Are the Baltic States significantly different from other CEE countries in respect to co-movements in the economic activity?

– To which extent does the real GDP growth in the euro area, Russia and CEE countries explain developments in real GDP growth in the Baltic States?

– Is the magnitude of the fluctuations in exports, consumption and investment relative to the fluctuations of real GDP growth similar in all Baltic States?

In line with the aims of the current paper, special attention will be given to the analysis of common factors in respect to the development of the Latvian economy.

In order to answer the above specified questions, three methods are employed:

– the static factor analysis, which helps to define countries similar in the development of economic activity;

[1] At the end of 2007.
[2] See, for example, (7).
[3] The theoretical foundations of currency unions have been developed in the literature on OCA pioneered by R. A. Mundell (22) and continued by R. I. McKinnon (17) and P. Kenen (14).

– the dynamic common factor model, which assesses the impact of common factor on the real standardised GDP growth of individual countries;

– the dynamic correlation, which helps to evaluate synchronisation between the growth cycles of GDP and its components for cycles of different frequency.

The paper is structured as follows. Section 1 lays out the methodology employed. Section 2 provides some details about the data. Section 3 presents the results of the research. It is divided into three main sub-sections, of which the first contains the results of the static factor model, the second presents the analysis of the dynamic factor model for four specifications, and the last deals with the results of the dynamic correlation employed. Section 4 concludes.

1. THE ANALYSIS OF BUSINESS CYCLE SYNCHRONISATION

The definition of business cycles has changed over time. In early studies, a business cycle, the so-called classical cycle, was defined as sequences of expansions and contractions in series representing the levels of economic development. This approach is typically associated with the NBER[4].

Later due to very high rates of real economic growth after World War II and a slowdown rather than absolute declines in the overall economic activity, a view that an economic time series should be decomposed into the sum of trend and cyclical components, commonly referred as a growth cycle[5], was developed. According to the OECD definition, a growth cycle is a more accurate definition of the cycles of economic activity where contractions (expansions) include not only absolute declines (increases), which is in line with the NBER approach, but also slowdowns (accelerations). The main questions in respect to the OECD approach are how the trend and cyclical component should be identified and estimated. In order to solve these issues, a range of parametric and non-parametric measures have been developed[6].

Since the end of the 1980s, business cycles have been viewed in a wider international context, taking into account the economic interactions of different countries. Special attention was given to the two features of the business cycle defined by A. F. Burns and M. C. Wesley in 1946: the co-movement of individual economic series and different behaviour of the economy during expansions and contractions.(3) These theoretical concepts were empirically proved by J. H. Stock and M. W. Watson (24; 25; 26) who used a dynamic factor model to capture co-movements by obtaining a single common factor from a set of many macroeconomic series, and J. D. Hamilton (12) who developed a nonlinear model with discrete regime switching between periods of expansion and contraction to assess the dynamics of real GNP.[7]

[4] See E. Mönch and H. Uhlig (19) for example of applied NBER methodology and Bry-Boshan procedure.
[5] The term "growth cycle" was introduced by OECD in 1960.
[6] See (18) and (29) for the overview of parametric and non-parametric measures of growth cycle.
[7] See F. X. Diebold and G. D. Rudebusch (8) for explicit representation of the two concepts.

The current paper focuses on the analysis of co-movements of economic indicators, particularly the real standardised quarterly GDP growth for the Baltic, CEE and euro area countries and Russia, and the real standardised quarterly growth of GDP components (exports, investment, and private consumption). Common factors estimated from dynamic factor models are used as indicators of common economic activity of the region. Special attention is paid to the analysis of common and specific factors that determine the development of the Latvian economic activity.

1.1 Factor Analysis: The Static Factor Model

Factor analysis is used to analyse interrelationships among a large number of variables and to explain these variables in terms of their common underlying dimensions called factors[8]. In this paper, factor analysis is used to define groups of countries that have common economic development.

There are a number of methods of extracting factors from a set of data. The most commonly used are the Principal Components Analysis (PCA) and the Principal Factor Analysis (PFA), also called the principal axis factoring or common factor analysis. PFA is a form of factor analysis to identify the least number of factors that can account for common variance (correlation) of a set of variables; PCA in its full form seeks to identify a set of factors that can account for all the common and unique (specific plus error) variance in a set of variables.[9] In addition to PCA and PFA, there are other extraction methods, e.g. Maximum Likelihood Factoring (ML), Unweighted Least Squares (ULS), Generalised Least Squares (GLS) and others.

In this paper, the ML technique is used. The ML factors are formed on the basis of a linear combination of variables where the parameter estimates are those most likely to have resulted in the observed correlation matrix (9). Correlations are weighted by uniqueness of each variable [10]. An iterative algorithm for this optimisation is detailed by K. G. Jöreskog.(13) In comparison with other methods, the advantage of ML and GLS for factor analysis is a possibility to evaluate the quality of the model and estimated results by using several statistical tests, e.g. the Bartlett chi-square statistic, incremental fit indices and others.

Rotation is a step in factor analysis which is usually necessary to facilitate the interpretation of factors. The estimated loadings and factors are not unique; an infinite number of other factors that fit the observed covariance structure identically can be obtained. In this way, a simpler factor structure can be obtained. The varimax rotation technique is used in the current paper. The varimax rotation is an orthogonal rotation of the factor axes to maximise variance of squared loadings of a factor.(9) This is the most common rotation option.

The main drawback of using a static factor model is that it does not allow for dynamics in the relationship between economic variables and the factor. Therefore

[8] For more details see P. Tryfos (28), Chapter 14.
[9] For more details on factor analysis see (15) and (10).
[10] Uniqueness is the variability of a variable minus its communality (the part that is explained by common factors).

many studies of the business cycle co-movements[11] have used the dynamic factor model approach.

1.2 The Dynamic Factor Model

According to the business cycle definition by A. F. Burns and M. C. Wesley[12], there are two important and indispensable features of the business cycle phenomenon: the co-movement of macroeconomic variables throughout the cycle and the asymmetry between expansions and recessions. The well-known dynamic factor methodology proposed by J. H. Stock and M. W. Watson (26) incorporates the first of these features by capturing the common dynamics (common factor) of different macroeconomic time series. It is assumed that there exists a common unobserved dynamic factor which underlies the co-movements of individual coincident economic variables and can be interpreted as the state of the economy.

The analysis of the second feature, asymmetry of business cycles, is presented by J. D. Hamilton (11) who developed a nonlinear model for real GDP with discrete regime switching between periods of expansion and contraction. In Hamilton's regime-switching model, the time-series dynamics is governed by an unobservable variable, which follows the first order Markov-chain process.

The current paper is based on the analysis of co-movement of economic indicators and follows the model specification of A. Monfort et al.(21). It is assumed that n-dimensional stochastic process $y_{i,t}$ $(i = 1,...,n)$ depends linearly on m unobservable factors z_t^k $(k = 1,...,m)$, which in turn follow the first order autoregressive process. The linear state-space model can be written in a matrix notation as follows:

$$\begin{aligned} Y_t &= AY_{t-1} + BZ_t + \varepsilon_t \\ Z_t &= DZ_{t-1} + \eta_t \end{aligned} \qquad [1]$$

where A and D are diagonal matrixes, ε_t and η_t are independent Gaussian white noise vectors. The variance-covariance matrix $V[\varepsilon]$ of disturbances ε_t is assumed to be diagonal:

$$V[\varepsilon] = \begin{bmatrix} \sigma^2{}_1 & & 0 \\ & \ddots & \\ 0 & & \sigma^2{}_n \end{bmatrix}$$

where $\sigma^2{}_i$ represents variances of the error term. The matrix B measures the instantaneous impact (factor loadings or sensitivities) of common factors on each series y_i.

[11] For more details see (20) and (21).
[12] See (8) for summary of the empirical definition of business cycle by A. F. Burns and M. C. Wesley.

An advantage of this specification is that it is fairly flexible and allows for distinguishing between the factors common for all y_i and factors common for a group of y_i (specific common factors). In the case of specific factors, a system of equations [1] can be decomposed into the following system of equations:

$$\begin{aligned} Y_t &= AY_{t-1} + BZ_t + CW_t + \varepsilon_t \\ Z_t &= D^z Z_{t-1} + \eta_t^z \\ W_t &= D^w W_{t-1} + \eta_t^w \end{aligned} \qquad [2]$$

where Z_t is the specific factor for a group of series and W_t is the common factor affecting all series[13]. The Kalman filter approach is used to estimate the parameters of the model[14].

1.3 The Dynamic Correlation

Any covariance-stationary process has both a time-domain representation and frequency domain representation, and any feature of the data that can be described by one representation can equally well be described by the other.(12) In other words, any covariance-stationary process can be represented as a sum of different frequency movements, presenting long, medium and short-term fluctuations of the analysed time series.

The dynamic correlation describes dynamic properties of univariate series through their spectrum. It permits to describe the sign and amplitude of co-movements according to different frequencies: from long-run relations to short-run movements.(28)

In this section, the dynamic correlation developed by C. Croux et al. (6) is used to evaluate synchronisation between the growth cycles of GDP and its components for cycles of different frequency. For example, if the time series of real standardised GDP growth are denoted by x and those of real standardised export growth by y, the dynamic correlation between the GDP and export growth (ρ_{xy}) could be defined as follows:

$$\rho_{xy}(\omega) = \frac{C_{xy}(\omega)}{\sqrt{S_x(\omega)S_y(\omega)}} \qquad [3]$$

where ω is the frequency of fluctuations in the range from 0 to π, $C_{xy}(\omega)$ is the real part of cross spectrum between x and y, or co-spectrum, and $S_x(\omega)$ and $S_y(\omega)$ are the spectrum of x and y.[15]

[13] See (21) for more details.
[14] For detailed methodology on the Kalman filter see (11).
[15] For more detail see (2), (6), (11) and (28).

2. DATA

The source of quarterly data for the period from 1995 to 2006 is the Eurostat database. The data have been seasonally adjusted using the Census X12 method. The data set is log-differenced and standardised to remove the scale effect of different economies and to ensure comparability of time series fluctuations. This provides the comparison of estimated coefficients between countries within the frame of a single model without implementing additional weights.

The quarterly real standardised GDP data for 19 European countries[16], Russia, the US and Japan are used to evaluate synchronisation of economic fluctuations in the global context and, as a result of analysis, to define homogenous EU regions, this being the key interest of the present research.

A full set of selected countries is used for the static factor analysis to get a complete picture of common factors that explain the co-movements in real standardised GDP growth of different countries. Due to computability issues[17], the number of countries used in the dynamic factor analysis has been reduced. The countries are subdivided into three main groups: the Baltic States (Latvia, Lithuania and Estonia), CEE countries (the Czech Republic, Hungary, Poland, Slovakia and Slovenia), as well as the euro area (France, Germany and Italy) and CIS (Russia).

The major components of final demand in the Baltic States – real exports, real private consumption and real gross fixed capital formation (investment), are used to assess the impact of common factors for the given components on the dynamics of the common factor for the real standardised GDP growth.[18]

3. RESULTS

3.1 Factor Analysis

In this section, the results of factor analysis, which was conducted to subdivide the reviewed countries into groups according to similarities in the real standardised GDP growth, and to define the share of each country's economic activity variation explained with a common factor, are presented.

The ML method is chosen for factor estimation. The analysis is based on ordinary correlation of data, and initial communalities are equal to squared multiple correlation. The number of factors is chosen from the analysis of eigenvalues (see Appendix 1). The eigenvalues of seven factors are significantly above the value 1. Alternative methods of defining the number of factors, e.g. fraction of total variance or minimum average partial method, give similar results.

The cumulative variance accounted for by the seven common factors is close to 72% of the total variance (see Appendix 2). Appendix 3 shows goodness-of-fit information for the estimated specification. The absolute fit index of Bartlett

[16] Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, the Netherlands, Poland, Slovakia, Slovenia, Spain, Sweden, the UK.
[17] The Kalman filter can not be used for large cross-sections of data.
[18] Government expenditure is not included in analysis due to the nature of public spending which appears to depend mainly on domestic motives and political decisions.

probability 0.74 and the zero probability results for the independence hypothesis as well as sufficiently high values of incremental fit indices suggest that the seven factors explain the variance of data adequately (see Appendix 3).

The analysis of communality (explained portion) and uniqueness (unexplained portion) of variable variance shows that the accounted factors explain a rather small part of variance for Poland and Spain, therefore the rotated loadings of factors for these countries should be evaluated with caution (see Appendix 4).

Factor rotation is necessary to simplify the factor structure and to ease the interpretation of estimated results. The orthogonal varimax method for factor rotation is used (see Appendix 5). The seven accounted factors can be interpreted as seven groups of countries with similar dynamics of real standardised GDP growth. In compliance with the country composition in each factor, it can be concluded that the static factor analysis confirms synchronised fluctuations of economic activity in the Baltic States; there are also some similarities in the development of Baltic and euro area economies. Also, some co-movements exist in economic activities of the euro area countries and the US, as well as euro area and CEE countries. The current analysis does not indicate any strong evidence in favour of common dynamics in the economic development of the CEE and Baltic countries. Likewise, fluctuations of the Japanese and Russian economies are to a lesser extent synchronised with those of the other countries under review.

In order to check the highlighted hypotheses, further investigation of communalities is conducted by applying the dynamic factor models. Since the Baltic and most of the CEE countries have joined the ERM II and synchronisation of economic activity of countries within the euro area is gaining importance, special attention in the current paper is given to the analysis of common fluctuations of real economic activity in the euro area, Baltic and CEE countries. In order to get a deeper understanding of the impact of Russia's economic activity, the Russian crisis in particular, on the economic activity of the Baltic States, Russia is also included in the analysis.[19]

3.2 Common Dynamic Factor Models of Real Standardised GDP Growth in the Baltic States

In this section, the results of four common dynamic models for the Baltic States are presented.

3.2.1 Common Factor for Real Standardised GDP Growth in the Baltic States

In order to estimate the common factor for real standardised GDP growth in the Baltic States, one factor model is employed. Parameter estimates for the model of one common factor are given in Table 1.[20]

[19] In the current paper the term "Russian crisis" is used to denote the financial crisis in Russia in 1998, which occurred as a result of unsustainable public debt dynamics and the needed correction to an overvalued real exchange rate. Detailed analysis of the crisis could be found in B. Pinto et al.(23)

[20] Here and hereinafter, standard error in parenthesis.

Table 1
Parameter estimates (model with one common factor)

	LV	EE	LT
$a_{i,i}$	–0.173 (0.148)	–0.206 (0.207)	–0.331 (0.167)
b_i	0.591*** (0.188)	0.843*** (0.146)	0.496*** (0.149)
σ_i	0.704*** (0.123)	0.423** (0.269)	0.779*** (0.107)
d	0.607*** (0.213)		
$Y_t = AY_{t-1} + BZ_t + \varepsilon_t$ $Z_t = dZ_{t-1} + \eta_t$ [21]			

Note: coefficient is significant at 1% (***), 5% (**) and 10% (*) level.

The lagged dependent variables are not significant, while the impact coefficients of common factor are all significant and similar in magnitude among countries. The impact of the common factor is statistically higher[22] for Estonia compared with that for Lithuania and Latvia; it is statistically equal for the two latter countries (see Appendix 6).

Table 2
Correlation between real standardised GDP growth series and common factor

	LV	EE	LT
$corr(Z, Y_i)$	0.717	0.941	0.576

The analysis of static correlation between the common factor for the Baltic States and real standardised GDP growth (see Table 2) indicates that on average the economic activity of Lithuania is less synchronised with the common factor and hence also with the fluctuations of the economy in Latvia and Estonia.

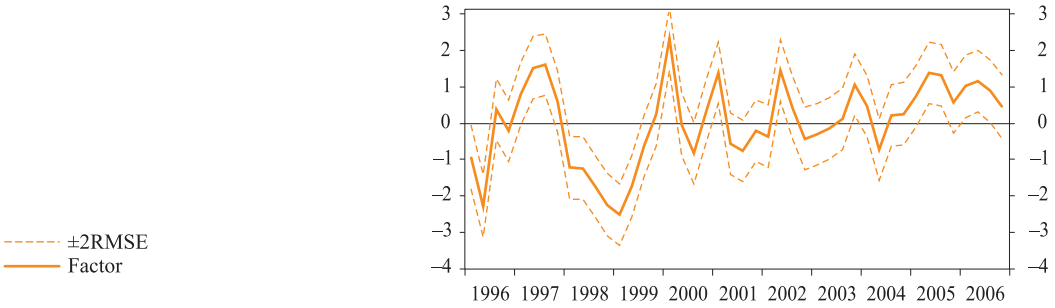
The graphical representation of the estimated common factor and real standardised GDP growth in the Baltic States (see Appendix 7) suggests that the estimated factor to a larger extent represents the economic activity in Estonia. The real standardised GDP growth of Latvia and Lithuania shows the presence of some additional specific fluctuations in the economic development of these countries. In contrast to Latvia and Estonia, Lithuania demonstrates stronger specific volatility and slower recovery from the Russian crisis.

As is seen from Chart 1, there are two specific medium-term deviations from the zero level in real GDP dynamics: the first corresponds to the negative exogenous shock in 1998 (Russian crisis) and the second captures the positive exogenous shock in 2004 (accession to the EU) and the following period of consistent and fast economic growth.

[21] Hereinafter, the variance of error term (η) is set at 1 (due to data standardisation and for identification purposes).
[22] At the 10% significance level.

Chart 1

Common factor for real standardised GDP growth of Latvia, Lithuania and Estonia (±2RMSE)



To assess the degree of synchronisation among countries and to investigate if there are any dynamics, the correlation analysis over 4-year moving window is estimated (see Appendix 8). The moving correlation between the obtained common factor and real standardised GDP growth for Estonia and Latvia is quite stable and even growing. The moving correlation for Lithuania during 2000–2002 is stable, but later the tendency changes with correlation gradually diminishing to the zero level in the fourth quarter of 2006. The period of stable correlation can be explained by a similar response to the Russian crisis and a further recovery in the next four-year period.

The low overall correlation for Lithuania and the downward slope of moving correlation after 2002 may be explained by the country's specific economic structure compared with other Baltic States. One of the possible reasons for it may be the large share of oil processing industry in the manufacturing sector and differences in the credit market development. For example, due to low inflation, the real interest rate in Lithuania remained positive up to 2005, which is not the case for Latvia and Estonia where the respective rate turned negative already in 2004 (see Appendix 9). Compared with other Baltic States, such dynamics of the real interest rate in Lithuania during the reviewed period stimulated private consumption to a lesser extent, bringing about moderation of the growth of domestic demand. Therefore Lithuania is the only Baltic country which does not show signs of economy overheating in the reviewed period after 2004, which is indicative of a moderate GDP growth level compared with the neighbouring countries.

3.2.2 Common Factors for Real Standardised GDP Growth in the Baltic States and CEE Countries

In order to check if there is a common factor in the development of real standardised GDP growth for the CEE and Baltic countries, the previous model is augmented by an additional common factor for the Baltic States and CEE, while retaining the common factor for the Baltic States.

The parameter estimates for the model are given in Table 3.

Table 3
Parameter estimates (model with two common factors)

	LV	EE	LT	CZ	HU	PL	SK	SI
$a_{i,i}$	–0.377	–0.175	–0.359	–0.210	–0.143	–0.184	–0.084	–0.527***
	(0.245)	(0.331)	(0.334)	(0.207)	(0.231)	(0.271)	(0.254)	(0.276)
c_i	0.453	–0.144	–0.016	0.120	–0.135	–0.236	0.432	0.241
	(0.535)	(0.719)	(0.544)	(0.507)	(0.288)	(0.362)	(0.660)	(0.405)
b_i	0.556**	0.747***	0.424*	–	–	–	–	–
	(0.315)	(0.330)	(0.281)	–	–	–	–	–
σ_i	0.383	0.469	0.836****	0.807****	0.802****	0.919****	0.827****	0.845****
	(0.769)	(0.606)	(0.156)	(0.177)	(0.142)	(0.158)	(0.339)	(0.162)
d^w	0.027 (0.609)							
d^z	0.535* (0.341)							
$Y_t = AY_{t-1} + CW_t + BZ_t + \varepsilon_t$								
$W_t = d^w W_{t-1} + \eta_t^w$ – *1st common factor (for Baltic and CEE countries)* $Z_t = d^z Z_{t-1} + \eta_t^z$ – *2nd common factor (for Baltic countries only)*								

Note: coefficient is significant at 1% (****), 5% (***), 10% (**) and 15% (*) level.

The impact of the common factor for the CEE and Baltic countries is not significant for all countries, implying that there is no common factor for the CEE and Baltic countries, and it is in line with the results of factor analysis dealt with in Section 3.1. The coefficients of the common factor for the Baltic States are significant and do not differ much from the values obtained from the one factor model (see Table 1); however, *b* coefficients are no longer statistically different (see Appendix 12), thus the hypothesis that the common factor for the Baltic States influences all countries equally can not be rejected.

The results of the correlation analysis of the common factor for the Baltic States are also very similar to those obtained by the one factor model (see Table 4 and Appendix 11).

Table 4
Correlation between real standardised GDP growth series and common factor

	LV	EE	LT
$corr(Z, Y_i)$	0.771	0.904	0.527

The main conclusion of this section is that the CEE and Baltic countries do not share a common factor that explains fluctuations in the real standardised GDP growth.

3.2.3 Common Factors for Real Standardised GDP Growth in the Baltic States and the Main Euro Area Countries

Similar to the analysis of the common factor for the CEE countries and Baltic States, the common factor in the development of real standardised GDP growth for the main euro area countries and Baltic States is estimated. A model with two common

factors, one for the Baltic States and euro area, and the other for the Baltic States, is estimated.

The parameter estimates are given in Table 5.

Table 5
Parameter estimates (model with two common factors)

	LV	EE	LT	IT	FR	DE
$a_{i,i}$	–0.273** (0.165)	–0.267 (0.195)	–0.409* (0.258)	–0.303** (0.172)	–0.295** (0.168)	–0.418*** (0.188)
c_i	0.506** (0.312)	0.655*** (0.314)	0.296 (0.248)	0.732**** (0.175)	0.792**** (0.219)	0.667**** (0.209)
b_i	0.445*** (0.233)	0.454*** (0.226)	0.323 (0.248)	– –	– –	– –
σ_i	0.677**** (0.125)	0.574**** (0.168)	0.781**** (0.169)	0.648**** (0.151)	0.586**** (0.148)	0.642**** (0.129)
d^w	0.407* (0.270)					
d^z	0.826**** (0.158)					
$Y_t = AY_{t-1} + CW_t + BZ_t + \varepsilon_t$						
$W_t = d^W W_{t-1} + \eta_t^w$ – *1st common factor (for the Baltic States and the main euro area countries)*						
$Z_t = d^z Z_{t-1} + \eta_t^z$ – *2nd common factor (for the Baltic States only)*						

Note: coefficient is significant at 1% (****), 5% (***), 10% (**) and 15% (*) level.

Compared with the one factor model, the coefficient *b* for the common factor of the Baltic States became smaller due to the inclusion of an additional factor, which picked up some explanatory power from the common factor for the Baltic States. Both factors have a significant impact on the development of real standardised GDP growth for Latvia and Estonia (coefficients for Lithuania are statistically significant only at the 20% confidence level). The common factor for the euro area and Baltic States as well as that for the Baltic States only have a statistically equal effect on the dynamics of real standardised GDP growth in Latvia and Estonia (see Appendix 13).

The value of static correlation coefficients shows that overall the first factor is highly synchronised with the real standardised GDP growth data for Italy, France and Germany, whereas the second – with the real standardised GDP growth for the Baltic States (see Table 6). The graphical representation of the first common factor and real standardised GDP growth for France, Italy and Germany (see Appendix 14) supports these findings. The dynamics of the common factor is generally in line with the fluctuations of economic climate in the euro area.(4)

Table 6

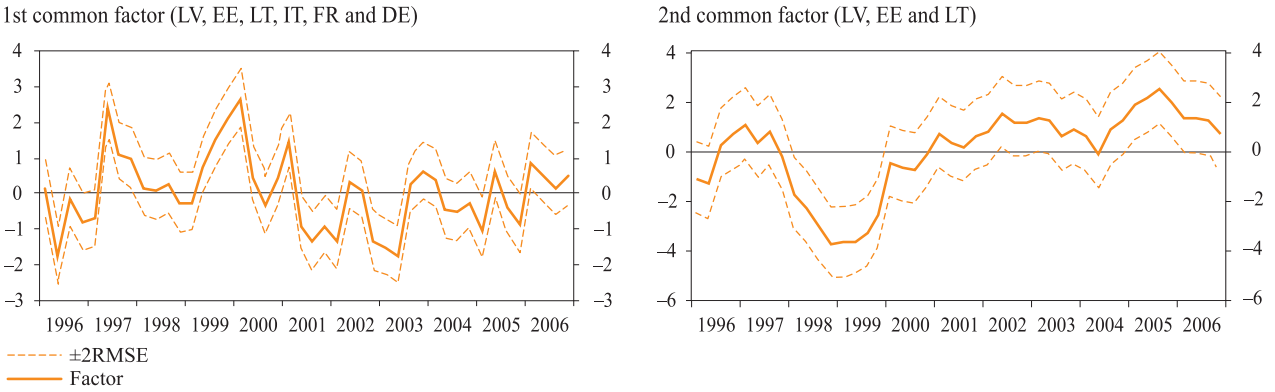
Correlation between real standardised growth series and common factors

	LV	EE	LT	IT	FR	DE
$corr(W, Y_i)$	0.331	0.496	0.250	0.785	0.815	0.701
$corr(Z, Y_i)$	0.576	0.563	0.426	–	–	–

The implementation of the second common factor decreased the volatility of the common factor for the Baltic States, thus the effect of economic fluctuations common for the euro area and Baltic States is removed from the second factor (see Chart 2).

Chart 2

Common factors for real standardised GDP growth in two factor model (±2RMSE)



Compared with the results of the one factor model (see Table 2), the inclusion of the common factor for the main euro area and Baltic countries decreases the correlation values between the series of real standardised GDP growth and common factor for the Baltic States (see Table 6). Together with statistically significant coefficients of b_i and c_i it indicates the subdivision of fluctuations of real standardised GDP growth between the factors and proves that the Baltic and euro area countries have a common development pattern.

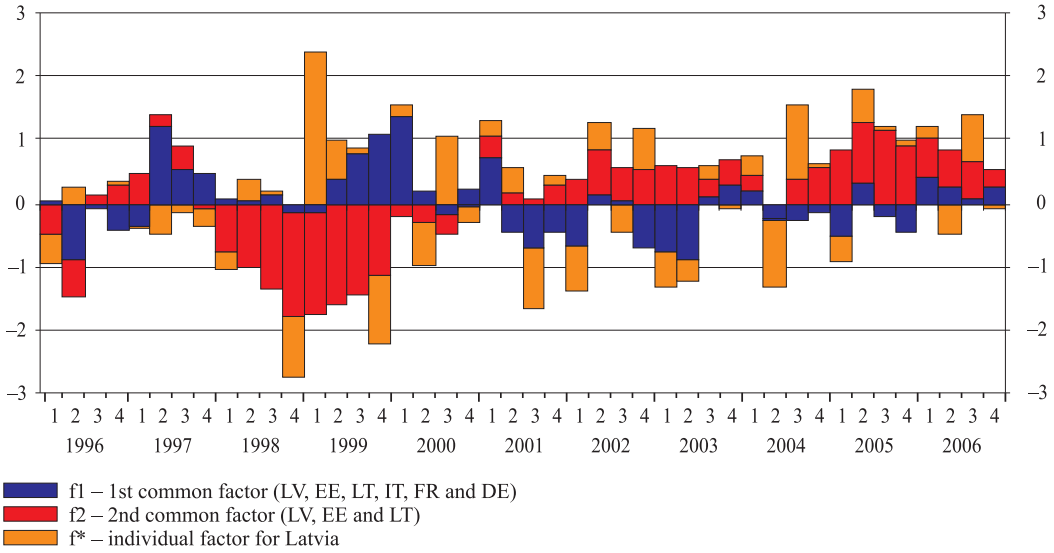
In order to analyse the contribution of each common factor to the economic growth of the respective country, the real standardised GDP growth has been subdivided according to the importance of common factors and the individual factor, which is defined as a part of economic activity growth not explained by common factors.

The contribution of estimated common factors to dynamics of Latvia's real standardised quarterly GDP growth is presented in Chart 3. The common factor for the Baltic States explains the slowdown of the Latvian economy due to the common response of the Baltic Region to the Russian crisis of 1998. There were two factors which sped up the recovery of the Latvian economy after the crisis. The first one is associated with the positive development of the euro area economic activity in 1999. The second one is related to the relatively fast recovery of export industries from the negative shock caused by devaluation of the Russian currency and the resulting narrowing of the Russian export market during the second half of 1998. The recovery might be explained by successful reorientation of exports from the Russian to European market as could be seen from the data presented in Appendix 15.

The contribution of the common factor for the Baltic States after 2001 is mostly positive, showing an overall positive economic development in the Baltic Region. Somewhat negative impact of the decline in the economic activity of the euro area was present in 2001 and 2003. After the accession to the EU, the common factor for the Baltic States represents a pronounced positive effect on the economy, supplemented by on average positive individual factor effect for Latvia.

Chart 3

Contribution of common and individual factors to dynamics of Latvia's real standardised GDP growth (two factor model)



The contribution of common factors to the dynamics of real standardised GDP growth in Latvia and Estonia is very similar, with a slightly more pronounced effect of the first factor common for the euro area and Baltic countries for Estonia (see Appendix 16). The results for Lithuania show that the individual factor has a much stronger effect compared with the neighbouring countries due to specific features of the Lithuanian economy discussed above.

The correlation over 4-year moving window between common factors and the series of the real standardised GDP growth of countries is presented in Appendix 17. The comparison of the results of the moving correlation for two and one factor models (see Appendix 8 and 17) shows that the inclusion of the common factor for the Baltic States and euro area countries caused a decrease in the moving correlation between the common factor for the Baltic States and the real standardised GDP growth. The additional factor explains fluctuations common for the euro area and Baltic States, hence decreasing the part which previously was explained by the common factor for Baltic States.

The results obtained for the 4-year moving correlation show that after 2000 the real standardised GDP growth in Latvia became more correlated with the common factor for real standardised GDP growth in the euro area and Baltic States. The Estonian real standardised GDP growth is highly correlated with the common factor for euro area and Baltic States during the entire period under review; it may be explained by

a bigger euro area share in the external trade of Estonia compared with the neighbouring countries.

After 2004, the share of exports from Latvia to the EU10 countries increased significantly (see Appendix 15) due to a strong growth of domestic demand in EU10, which induced an increase in imports of goods and services (see Appendix 18). Together with a moderate economic growth in EU12, it determined a change in the structure of exports from the Baltic States to EU (see Appendix 19). The share of foreign trade to EU12 decreased (see Appendix 20) mainly due to a decrease in export share. The decline observed in the share of exports to the euro area after 2004 explained the recorded decrease in the value of 4-year moving correlation between the first factor (common for the Baltic States and euro area) and the real GDP growth series (see Appendix 17).

3.2.4 Common Factors for Real Standardised GDP Growth in the Baltic States, Main Euro Area Countries and Russia

In order to evaluate the impact of the Russian economic activity and, in particular, the crisis of 1998 on the development of Baltic economies, the two factor model used in Section 3.2.3 was augmented by a third factor common for Russia and the Baltic States.

The estimated results of the three factor model are presented in Table 7.

Table 7
Parameter estimates (model with three common factors)

	LV	EE	LT	IT	FR	DE	RU
$a_{i,i}$	–0.280	–0.312*	–0.460	–0.253	–0.319*	–0.425**	–0.228
	(0.211)	(0.215)	(0.325)	(0.322)	(0.214)	(0.226)	(0.476)
c_i	0.450*	0.679**	0.337	0.777*	0.813*	0.705*	–
	(0.324)	(0.412)	(0.373)	(0.264)	(0.297)	(0.262)	–
$b_{1,i}$	0.389*	0.451**	0.406	–	–	–	–
	(0.260)	(0.270)	(0.312)	–	–	–	–
$b_{2,i}$	0.295	0.267	–0.046	–	–	–	0.781
	(0.280)	(0.200)	(0.367)	–	–	–	(0.578)
σ_i	0.577****	0.504****	0.723****	0.623****	0.585****	0.654****	0.398
	(0.171)	(0.202)	(0.187)	(0.183)	(0.180)	(0.180)	(0.962)
d^w	0.324 (0.478)						
d_1^z	0.769**** (0.248)						
d_2^z	0.575** (0.315)						
$Y_t = AY_{t-1} + CW_t + B^1 Z_t^1 + B^2 Z_t^2 + \varepsilon_t$							
$W_t = d^w W_{t-1} + \eta_t^w$ – *1st common factor (for Baltic, main euro area countries and Russia)*							
$Z_{1,t} = d_1^z Z_{1,t-1} + \eta_{1,t}^z$ – *2nd common factor (for Baltic countries only)*							
$Z_{2,t} = d_2^z Z_{2,t-1} + \eta_{2,t}^z$ – *3rd common factor (for Baltic countries and Russia)*							

Note: coefficient is significant at 1% (****), 5% (***), 10% (**) and 15% (*) level.

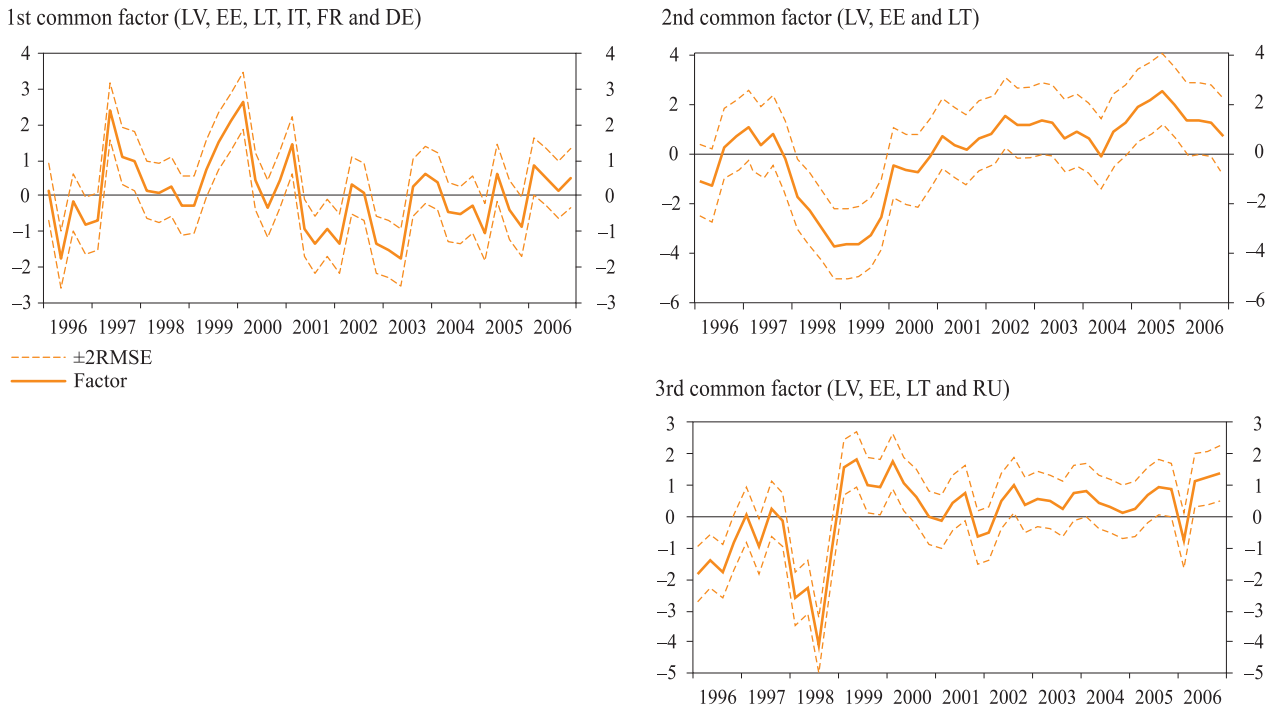
Compared with the two factor model described in Section 3.2.3, the coefficient values of the first and second common factor do not change significantly. Also, the coefficient values for each of the factors are statistically equal for the neighbouring countries, suggesting that the obtained factors have similar impact on the economic activity in Latvia, Lithuania and Estonia (see Appendix 21).

The results of the third common factor show that the coefficients of the common factor for the Baltic States and Russia are not statistically significant. However, the graphical representation of the extracted common factor (see Chart 4) shows that there are two well-defined and statistically significant periods in the development of Russian economy that are important for the explanation of economic fluctuations in the Baltic States captured by the third common factor: the period of the Russian crisis and the period of strong economic development after 2006. The Russian economic growth in 2006 (except the decrease in the first quarter of 2006 due to a slowdown in investment and export growth and stabilisation of consumption growth) has a positive effect on the growth of economic activity in the Baltic States.

The comparison of common factors for the real standardised GDP growth in the Baltic States obtained from two and three factor models with and without a specific factor for Russia (see Appendix 22) shows that the inclusion of the common factor for the Baltic States and Russia influenced the dynamics of common factor for the Baltic States during 1998–1999. The decline in economic activity in the Baltic States has a less pronounced trough in the second half of 1998 due to the exclusion of the Russian crisis pattern represented by a sharp drop in the GDP growth (see Chart 4, the third common factor).

Chart 4

Common factors for real standardised GDP growth in three factor model (±2RMSE)



The results of static correlation over the reviewed period (see Table 8) show additional lowering of correlation values between the common factor for the Baltic States and series of real standardised GDP growth of the countries due to the inclusion of additional common factor. The common factor for the Baltic States and Russia is mainly formed by the dynamics of the Russian real standardised GDP growth. The average correlation of Latvia and Estonia with this factor is rather high (0.379 and 0.309) mainly due to a similar response to the Russian crisis of 1998. It should be mentioned that on average Estonia has a more pronounced synchronisation of economic activity fluctuations with the main euro area countries; Latvia, on the other hand, on average is equally correlated with the common factors for the Baltic States and Russia, and the Baltic States and euro area.

Table 8

Correlation between series of real standardised GDP growth and common factors

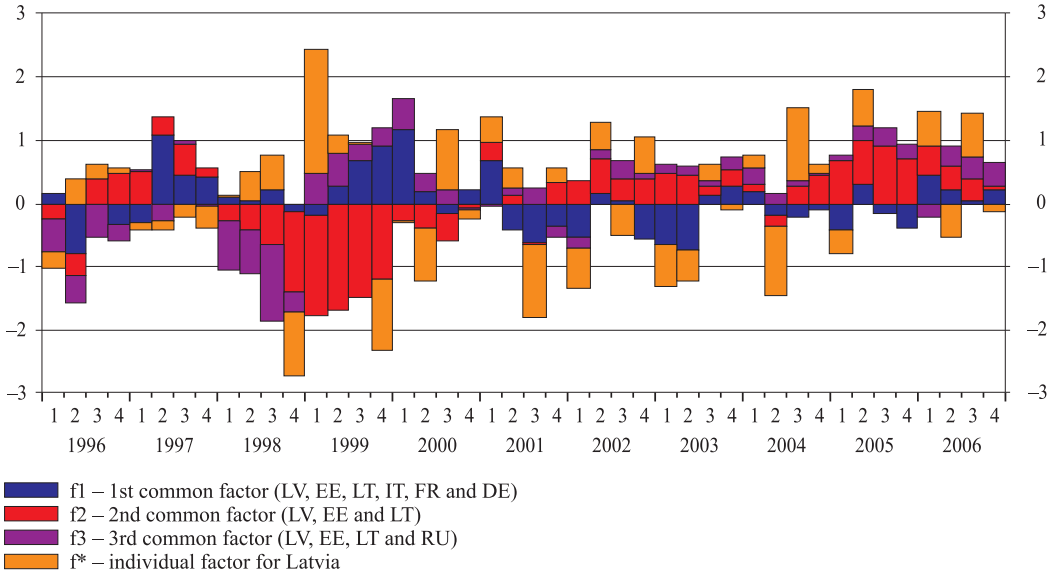
	LV	EE	LT	IT	FR	DE	RU
$corr(W, Y_i)$	0.331	0.509	0.272	0.800	0.814	0.709	–
$corr(Z^1, Y_i)$	0.504	0.520	0.482	–	–	–	–
$corr(Z^2, Y_i)$	0.379	0.309	–0.061	–	–	–	0.947

The graphical representation of the common factor contributions to dynamics of the real standardised GDP growth for Latvia is shown in Chart 5. The common factor for the Baltic States and Russia captures the part of the Latvian real standardised GDP growth that is explained by the development of economic activity in Russia. Deceleration in Russia's economic activity in the first half of 1998, which resulted from negative tendencies in the global financial market, and the financial crisis in Russia in the second half of 1998 have been removed from the common factor for the Baltic States. As can be seen from Chart 5, the recovery of the Russian economy after 1998 and acceleration of the economic growth in 2006 have a positive impact on the real standardised GDP growth in Latvia.

The common factor for the Baltic States and Russia has a smaller effect on the Estonian economy (see Appendix 23). The response of the Lithuanian economy to the Russian crisis was weaker and the following recovery slower compared with the neighbouring countries. In the present study, the structure of the dynamic factor model is defined as a first order autoregressive process, therefore the effect of the economic growth in Russia on the GDP growth in Lithuania should be evaluated with caution (see Appendix 23). The correlation over 4-year moving window for three and two common factors (see Appendix 17 and 24) shows that the inclusion of additional common factor (for the Baltic States and Russia), as in the previous section, caused an additional decrease in the moving correlation for all Baltic States from 2000 to 2002. Correlation of the real standardised GDP growth for Latvia, Lithuania and Estonia with the third factor common for the Baltic States and Russia indicates that until 2002 the correlation for Estonia and Latvia is stable and rather small due to a similar response to the Russian crisis as discussed earlier. After 2002, when the impact of the crisis is excluded from the analysis, the moving correlation between the real standardised GDP growth for Latvia and Estonia and the third factor common for the Baltic States and Russia becomes less stable and, on average, smaller (see Appendix 24).

Chart 5

Contribution of common and individual factors to dynamics of Latvian real standardised GDP growth (three factor model)



3.2.5 Common Factors for GDP Component Growth in the Baltic States

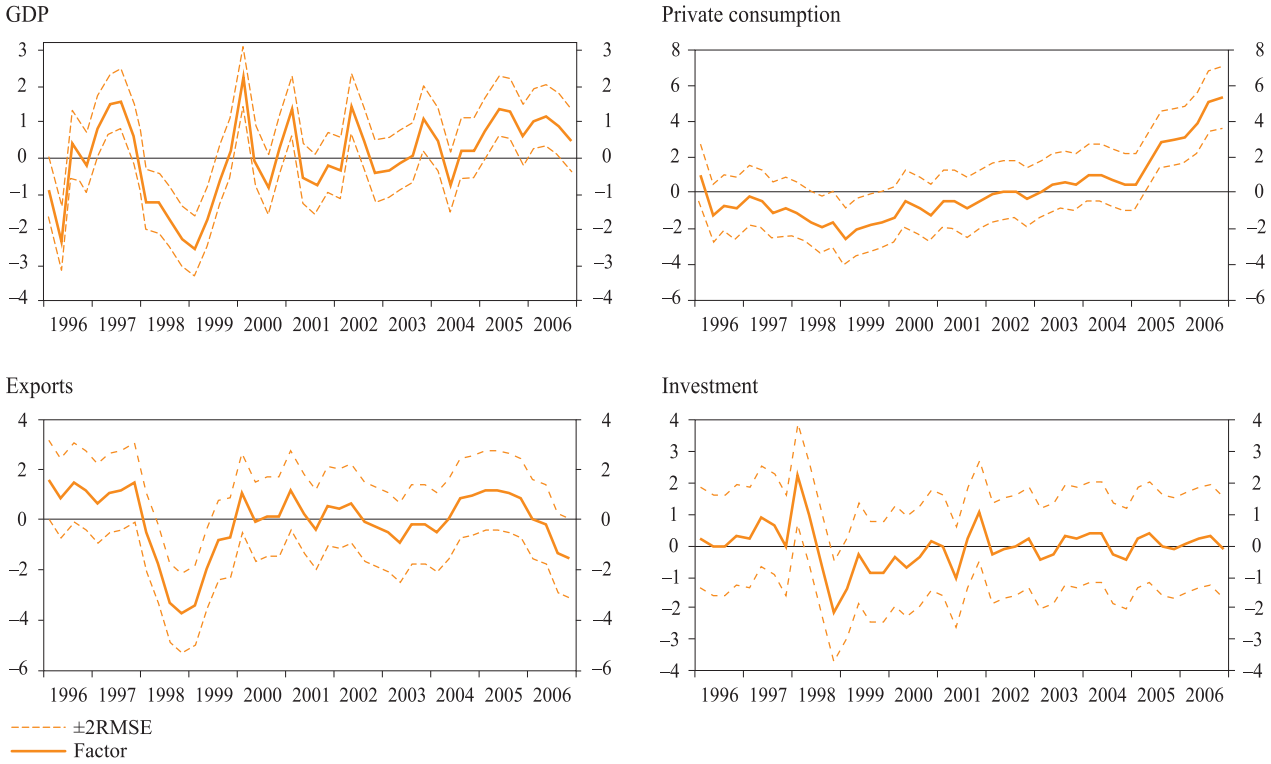
The synchronisation of GDP components is discussed in this section. Three components of GDP (exports, private consumption and investment (gross fixed capital formation)) are examined using the above specified dynamic common factor model with one common factor.

In order to identify which components are more important in explaining the real standardised GDP growth, three newly developed common demand component factors are presented together with the common factor for the real standardised GDP growth in the Baltic States (see Chart 6).

According to the common factor for consumption in the Baltic States, there are three main periods of consumption development: 1) period of overall decline in consumption growth from 1996 to 1999 (at the beginning of 1999, the decrease in the common consumption factor is statistically significant), 2) period of steady consumption growth from 1999 to 2005, and 3) period of consumption boom in 2005 and 2006. The factors that influenced the consumption growth during the last period, were easy access to cheap credit, increasing competition in the domestic banking sector and overall high positive expectations of economic agents after the accession to the EU. In 2005–2006, the consumption growth accelerated significantly and became a strong driving force of the GDP growth in all countries.

Chart 6

Comparison of common factors for models of real standardised GDP growth and its components in the Baltic States (±2RMSE)



The development of the common factor for exports may be subdivided into three periods. The first period is represented by on average a constant level of common factor from 1996 to 2004, with a sharp drop in export volumes due to the Russian crisis. The dynamics of the common factor for exports explains the dynamics of the common factor for the real standardised GDP growth in the Baltic States in 1998–2000 better than other GDP components. The second period (2004–2005) corresponds to the positive exogenous shock to the common factor of exports due to the accession of new member states to the EU in 2004 which caused a significant increase in final demand and import volumes of these countries (see Appendix 18) and hence also in the export share to the region (see Appendix 19). The last period is characterised by a slowdown in the total export activity in the Baltic States in 2006.

The common factor for investment, according to the results of Pairwise Granger Causality test, appears to respond with a lag to developments in the common factor for the real standardised GDP growth in the Baltic States (see Appendix 25). The obtained factor shows a decrease in investment growth at the end of 1998 as a consequence of an overall decline in the economic activity after the Russian crisis.

3.3 Drivers of Co-Movement: An Analysis of Dynamic Correlation of GDP Components in the Baltic States

The above findings show that there is a common factor in the real standardised GDP growth for Latvia, Lithuania and Estonia. To assess sustainability of the economic development of the countries, the dynamic correlation of exports, private

consumption and gross fixed capital formation growth versus series of real standardised GDP growth is estimated for each country.

The computation of dynamic correlation requires estimating the empirical spectral density matrix of above mentioned variables. To do so, the empirical auto-covariance function is estimated and smoothed with a Bartlett window[23]. The graphical representation of the results is presented in Appendix 26.

The correlation results are analysed for three groups of frequency band: long-run co-movements [0, π/16] corresponding to cycles with a period longer than 8 years (long-term dynamics), medium-term co-movements [π/16, π/3] corresponding to cycles with a period between 1.5 and 8 years (the dynamics of midterm economic activity)[24], and short-run co-movements corresponding to cycles with a period less than 1.5 years. More attention is paid to the two first groups by assessing the medium- and long-term co-movements between the series of real standardised GDP growth and its components.

The dynamic correlation estimated for the growth series of exports, consumption, investment and GDP shows that the Baltic States differ in impact of the main GDP components.[25] According to the results estimated over the reviewed period, the long-term growth of real GDP for Latvia is mainly correlated with the growth of private consumption; in the case of Estonia, investment and consumption are both important; for Lithuania, the input of all three components is similar, indicating a well-balanced development of the economy.

In the medium term, the correlation of all three components with the real standardised GDP growth for Estonia is between 0.5 and 0.8 implying high synchronisation of the analysed time series. For Latvia, the medium-term correlation of the real GDP growth with the dynamics of investment and exports is growing, reaching the maximum at the 3-year frequency band (~0.5). In the case of Lithuania, the correlation between exports and real standardised GDP growth is stable over different frequencies, which is a sign of pronounced impact of export growth on the country's GDP development.

[23] For details on nonparametric estimates see (12).
[24] The specification of frequency interval used in the current paper is in line with that in a wide range of research literature. See, for example, (1), (4) and (16).
[25] The dynamic correlation between GDP and investment series is calculated for GDP with two lags based on the results of Pairwise Granger Causality (Appendix 25).

CONCLUSIONS

The paper identifies a number of stylised facts about the observed common fluctuations of economic activity for the real standardised GDP growth in the Baltic, CEE and main euro area countries as well as Russia.

Three methods are employed: the static factor analysis, the dynamic common factor model, and the dynamic correlation. The factor analysis is used to form a hypothesis about the existence of potential common development of country groups. The dynamic factor models are used to extract common fluctuations in the economic activity of countries (common factors) and the contribution of those factors to the growth of real standardised GDP for each country. The dynamic correlation is used to evaluate synchronisation of growth cycles of GDP components determining the dynamics of final demand and the overall economy for cycles of different frequency.

The first specification of the dynamic factor model represents a model with one common factor for the Baltic States. The obtained results prove that the Baltic economies experience a common pattern of development. The 4-year moving correlation between the common factor and series of real standardised GDP growth for Estonia and Latvia represents a high level of synchronisation. The moving correlation coefficients for Lithuania are rather small and decreasing over time likely due to the specific economic structure of the country compared with other Baltic States.

The second specification is developed for the purpose of examining the existence of a common factor for the economic activity of the Baltic and CEE countries. One factor dynamic model is expanded to form a two factor model by adding a common factor for the CEE and Baltic countries. The results indicate that the two groups of EU10 countries are not similar in factors determining the real GDP growth, which is in line with the hypothesis formulated on the basis of the results of factor analysis.

The next specification is similar to the previous one, examining the existence of a common factor for the economic activity of the Baltic States and the main euro area countries. Both the common factor for the euro area and Baltic States as well as the one for the Baltic States have statistically significant equal effect on the dynamics of the real standardised GDP growth in Latvia and Estonia.

In order to analyse the input of common factors into the economic growth of a country, the contribution of each estimated common factor to the dynamics of economic activity of each particular country is calculated. The common factor for the Baltic States explains the major slowdown of Baltic economies in 1998–1999, positive development of economic activity after 2001, and the pronounced positive effect after the accession to the EU in 2004. The common factor for the Baltic States and euro area reflects the positive development of the euro area economy in 1999 that helped the Baltic States to overcome the negative effect of the Russian crisis on their economies by reorienting exports to the European markets. Also, the common factor for the Baltic and euro area countries captures some negative effect of the decline in the euro area economic activity in 2001 and 2003 on the development of real GDP growth in the Baltic States.

The results of 4-year moving correlation between the common factor and series of the real standardised GDP growth of countries show that after 2000 the real standardised GDP growth in Latvia became more correlated with the GDP growth of the main euro area countries. The Estonian real standardised GDP growth is highly correlated with the common factor for the euro area and Baltic States during the entire period under review due to a bigger euro area share in the external trade of Estonia compared with the neighbouring countries. The observed decline in correlation between the real GDP growth series and common factor for the Baltic States and euro area after 2004 may be explained by an increase in export share to EU10 countries that decreased the share of exports to euro area countries.

The last specification is extended by the inclusion of a third factor common for the Baltic States and Russia. The selection of this model structure is determined by historically close trade relations among these countries. The analysis of co-movements in the Baltic and main euro area countries as well as Russia removes the effect of economic fluctuations in euro area countries and Russia from the common factor for the Baltic States. Therefore the common factor for the Baltic States obtained from the three factor model captures economic fluctuations that are common only for the Baltic States. The common factor for the Baltic States and Russia depicts the part of real standardised GDP growth which is mainly explained by the development of economic activity in Russia. The common factor coefficients for the Baltic States and Russia are not statistically significant; however, two well-defined and statistically significant periods affecting the development of real GDP growth in the Baltic States are captured, i.e. the period of the Russian crisis in 1998, and the period of strong development of the Russian economy after 2006.

The 4-year moving correlation between the real standardised GDP growth of the Baltic States and the common factor for the Baltic States and Russia indicates that until 2002 correlation for Estonia and Latvia is stable and rather high due to their similar response to the Russian crisis of 1998. After 2002, when the impact of crisis is excluded from the analysis, the moving correlation for Latvia and Estonia becomes less stable and is on average smaller.

In order to explore the role of the main final demand components (exports, consumption and investment) in explaining fluctuations in the real standardised GDP growth, three common factors are developed. According to the common factor for private consumption in the Baltic States, there are three main periods of private consumption development. The last observed period that influenced the real GDP growth most represents a private consumption boom in 2005–2006 when consumption growth increased significantly and became a strong driving force of GDP growth in all countries. The common factor for investment appears to respond with a lag to developments in the common factor for the real standardised GDP growth in the Baltic States. This factor reflects the strong negative impact of the Russian crisis and overall decline in the economic activity on investment growth at the end of 1998. The dynamics of the common factor for exports explains the dynamics of the common factor for the real GDP growth in the Baltic States in 1998–2000 to a larger extent than other GDP components. The positive exogenous shock to the common factor of exports due to the accession of new EU countries in 2004 caused a significant increase in the final demand of these countries and hence also an increase in the share of exports to the region. The end of 2005 and year 2006

are characterised by a slowdown in the overall export activity in the Baltic States that also limited the increase in the real GDP growth.

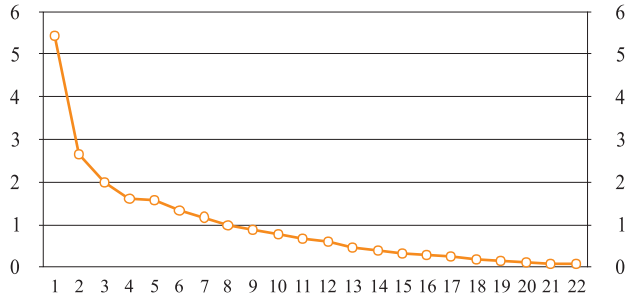
The dynamic correlation estimated for the growth series of exports, consumption, investment and GDP shows that the Baltic States differ in impact of the main GDP components. According to the results estimated over the reviewed period, the long-term growth of real GDP for Latvia is mainly correlated with the growth of private consumption; in the case of Estonia, investment and consumption are both important; for Lithuania, the input of all three components is similar indicating a well-balanced development of the economy. In the medium term, the correlation of the real GDP growth with the dynamics of exports and investment for Latvia is growing. The correlation of all three components with the GDP growth for Estonia in the medium term is of similar importance. In the case of Lithuania, the correlation between exports and real GDP growth is stable over periods of different frequency, which is a sign of pronounced impact of export growth on the country's GDP development.

The paper provides a number of interesting insights for future research. A particular line of investigation would refer to the deepening of understanding about economic determinants of common fluctuations and area linkages. For that purpose, a more careful analysis of international transmission channels of country-specific shocks would be useful.

APPENDICES

Appendix 1

The number of factors defined by minimum eigenvalue



Appendix 2

Eigenvalue summary

Number	Value	Difference	Proportion	Cumulative value	Cumulative proportion
1	5.416	2.776	0.246	5.416	0.246
2	2.640	0.649	0.120	8.055	0.366
3	1.991	0.374	0.091	10.046	0.457
4	1.617	0.048	0.074	11.663	0.530
5	1.568	0.242	0.071	13.231	0.601
6	1.326	0.143	0.060	14.557	0.662
7	1.183	0.199	0.054	15.740	0.716
8	0.984	0.095	0.045	16.725	0.760
9	0.890	0.089	0.040	17.614	0.801
10	0.800	0.124	0.036	18.414	0.837
11	0.677	0.060	0.031	19.091	0.868
12	0.617	0.154	0.028	19.708	0.896
13	0.463	0.073	0.021	20.170	0.917
14	0.389	0.082	0.018	20.560	0.935
15	0.307	0.015	0.014	20.867	0.949
16	0.293	0.054	0.013	21.160	0.962
17	0.238	0.046	0.011	21.398	0.973
18	0.193	0.063	0.009	21.591	0.981
19	0.130	0.012	0.006	21.721	0.987
20	0.118	0.031	0.005	21.839	0.993
21	0.086	0.011	0.004	21.925	0.997
22	0.075	–	0.003	22	1

Appendix 3

Goodness-of-fit summary

	Model	Independence
Absolute fit indices		
Bartlett probability	0.737	0.000
Akaike criterion	–1.579	2.130
Hannan-Quinn criterion	–3.053	–1.344
Incremental fit indices		
Bollen Incremental (IFI)	0.938	x
Bentler Comparative (CFI)	0.912	x

Appendix 4

Unrotated loadings matrix

	F1	F2	F3	F4	F5	F6	F7	Com-munality	Unique-ness
LT	–0.073	0.337	0.406	0.130	0.419	0.187	–0.246	0.571	0.429
LV	0.000	–0.138	0.959	0.248	0.000	0.000	0.000	1.000	0.000
EE	0.102	0.034	0.482	0.439	0.318	0.020	–0.313	0.636	0.364
AT	0.272	0.500	0.092	–0.062	0.029	–0.270	0.068	0.415	0.585
BE	0.613	–0.102	0.256	0.158	–0.407	–0.370	–0.011	0.778	0.222
DK	0.482	0.313	0.128	0.034	–0.223	0.150	0.166	0.448	0.552
DE	0.636	0.336	0.312	0.112	–0.214	0.309	0.021	0.769	0.231
ES	0.092	0.149	0.207	0.243	0.157	0.051	–0.225	0.210	0.790
FI	0.391	–0.083	0.171	0.275	0.202	0.414	0.026	0.478	0.522
FR	0.684	0.267	0.213	0.007	0.108	0.203	–0.274	0.712	0.288
IT	0.663	0.214	0.321	0.219	0.403	–0.065	–0.022	0.803	0.197
NL	0.614	0.348	0.221	–0.010	–0.432	–0.008	–0.051	0.736	0.264
SE	0.605	0.233	0.262	–0.027	0.390	–0.083	0.244	0.708	0.292
HU	0.316	0.384	0.085	–0.014	0.416	–0.358	0.240	0.613	0.387
PL	0.238	–0.073	–0.149	0.037	–0.043	–0.074	–0.072	0.098	0.902
SK	–0.380	0.154	0.535	–0.036	–0.206	0.298	0.231	0.640	0.360
SI	0.306	0.511	0.092	0.149	0.100	0.251	0.281	0.537	0.463
CZ	–0.066	–0.048	–0.026	0.228	0.251	0.051	0.500	0.375	0.625
UK	0.000	0.980	0.054	0.192	0.000	0.000	0.000	1.000	0.000
RU	–0.188	0.049	0.203	0.199	–0.075	–0.463	–0.161	0.364	0.636
US	0.458	0.014	–0.271	0.085	–0.378	0.159	0.084	0.465	0.535
JP	0.000	0.000	0.000	1.000	0.000	0.000	0.000	1.000	0.000

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	3.556	3.556	1.227	0.266	0.266
F2	2.330	5.886	0.046	0.174	0.441
F3	2.284	8.170	0.626	0.171	0.612
F4	1.658	9.827	0.103	0.124	0.736
F5	1.554	11.382	0.438	0.116	0.852
F6	1.117	12.499	0.258	0.084	0.936
F7	0.859	13.357	–	0.064	1
Total	13.357	64.677	x	1	x

Appendix 5

Rotated loadings matrix

	F1	F2	F3	F4	F5	F6	F7
LT	–0.215	0.351	0.380	0.059	0.219	0.111	0.440
LV	0.150	–0.081	0.959	0.152	0.131	–0.049	0.091
EE	–0.019	0.051	0.457	0.384	0.254	–0.042	0.458
AT	0.246	0.428	–0.037	–0.106	0.354	–0.179	–0.029
BE	0.763	–0.183	0.117	0.140	0.206	–0.288	–0.066
DK	0.535	0.250	0.025	–0.010	0.184	0.246	–0.065
DE	0.680	0.262	0.176	0.042	0.216	0.368	0.153
ES	0.033	0.148	0.176	0.207	0.128	0.004	0.311
FI	0.168	–0.108	0.147	0.260	0.255	0.485	0.221
FR	0.499	0.147	0.030	–0.036	0.383	0.235	0.487
IT	0.305	0.105	0.155	0.179	0.738	0.098	0.297
NL	0.802	0.256	0.054	–0.069	0.119	0.026	0.064
SE	0.241	0.117	0.103	–0.059	0.774	0.153	0.031
HU	0.008	0.297	–0.040	–0.036	0.703	–0.145	–0.082
PL	0.179	–0.117	–0.194	0.062	0.074	–0.041	0.061
SK	–0.067	0.259	0.623	–0.120	–0.275	0.215	–0.212
SI	0.203	0.478	0.032	0.094	0.326	0.383	–0.068
CZ	–0.244	–0.010	0.052	0.239	0.255	0.226	–0.374
UK	0.110	0.978	–0.012	0.100	0.134	–0.010	0.063
RU	–0.019	0.083	0.206	0.175	–0.024	–0.532	0.007
US	0.531	–0.042	–0.325	0.105	–0.062	0.228	–0.097
JP	0.035	0.091	0.103	0.990	0.001	0.005	0.016

Appendix 6

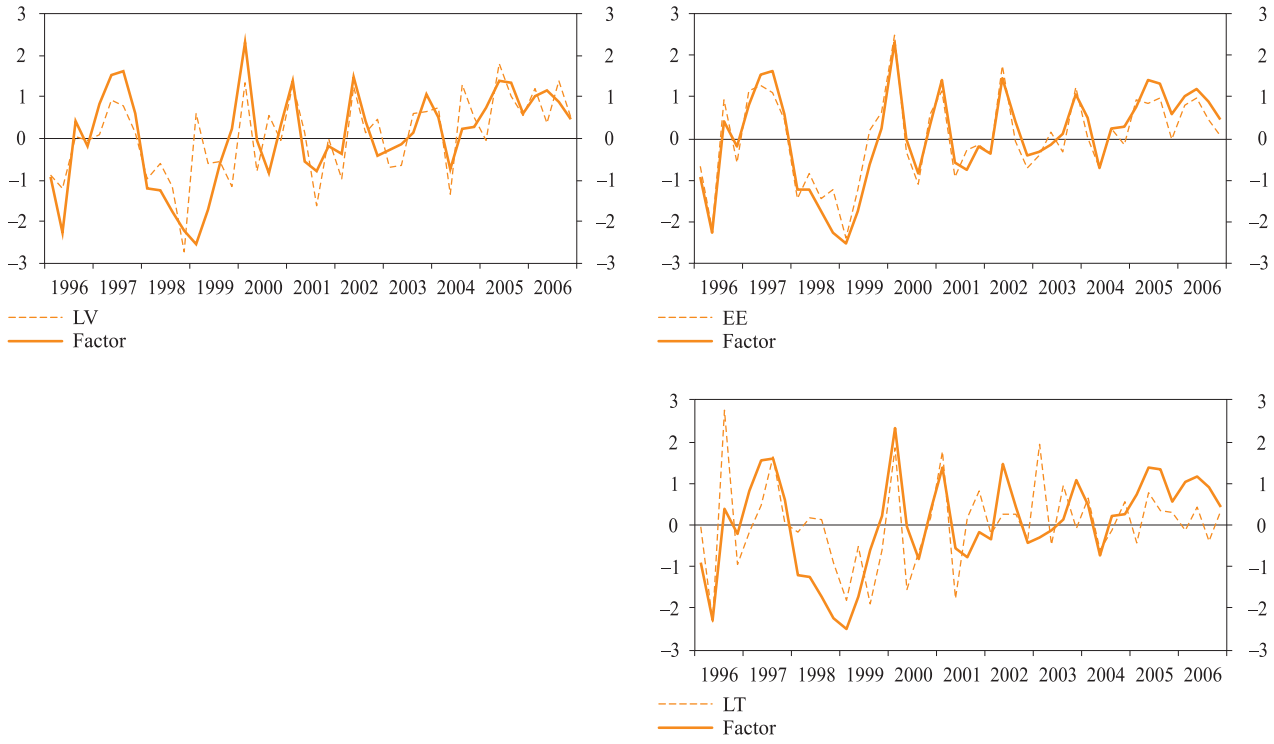
Wald statistics

(one factor model; Baltic States)

	Chi-square value	df	Probability
$b_{LV} = b_{LT}$	0.475	1	0.491
$b_{LV} = b_{EE}$	1.062	1	0.303
$b_{EE} = b_{LT}$	2.829	1	0.093

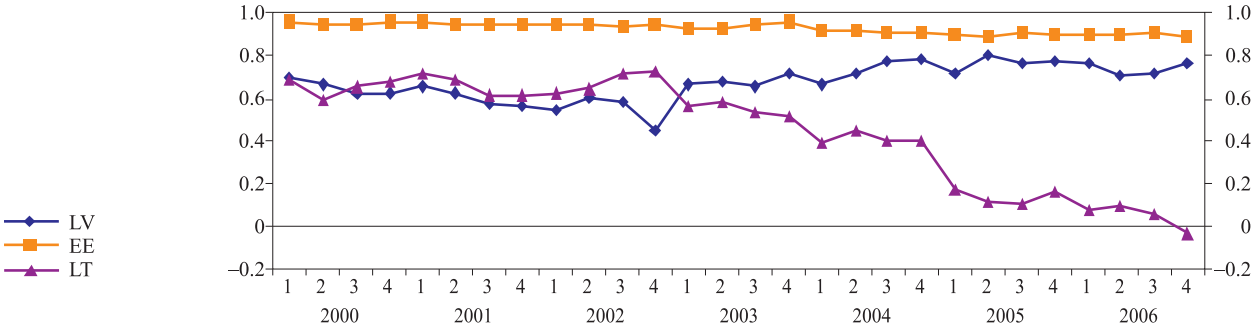
Appendix 7

Real standardised GDP growth in Latvia, Lithuania and Estonia: actual series and common factor



Appendix 8

Correlation between series of real standardised GDP growth and common factor for Baltic States computed over 4-year moving window (Latvia, Lithuania and Estonia)



Appendix 9

Real 3-month interest rate* (Estonia, Latvia and Lithuania; 2002–2006)

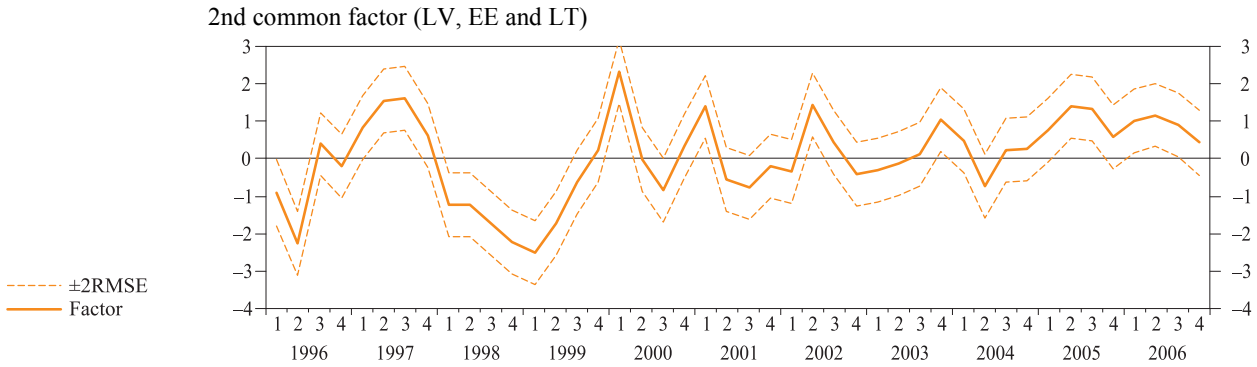
	2002	2003	2004	2005	2006
Estonia	1.66	2.46	–0.08	–1.56	–1.97
Latvia	4.82	1.38	–2.20	–2.49	–3.30
Lithuania	5.57	4.89	1.68	0.02	–1.32

* 3-month interest rate index versus HICP year-on-year index.

Source: Eurostat database.

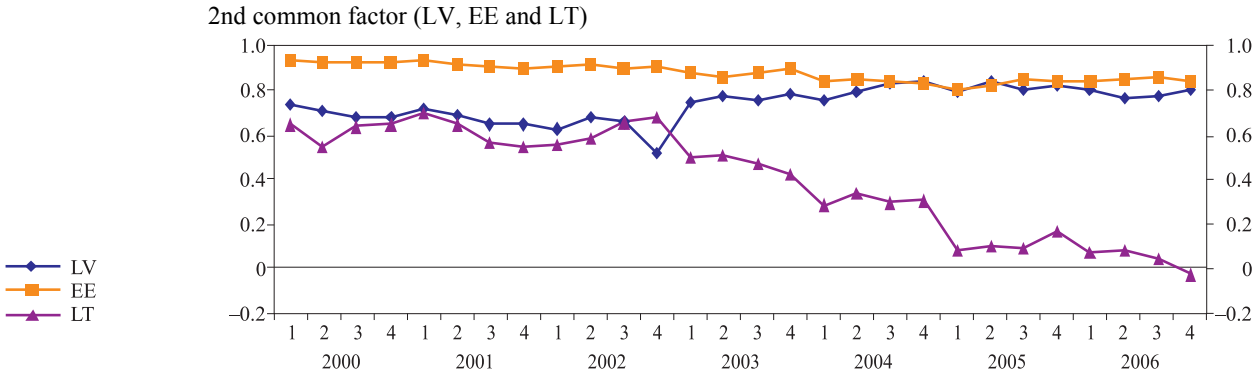
Appendix 10

Common factor for real standardised GDP growth in two factor model (CEE and Baltic States)



Appendix 11

Correlation between series of real standardised GDP growth and common factor computed over 4-year moving window (Baltic States and CEE countries)



Appendix 12

Wald statistics

(two factor model; CEE countries and Baltic States)

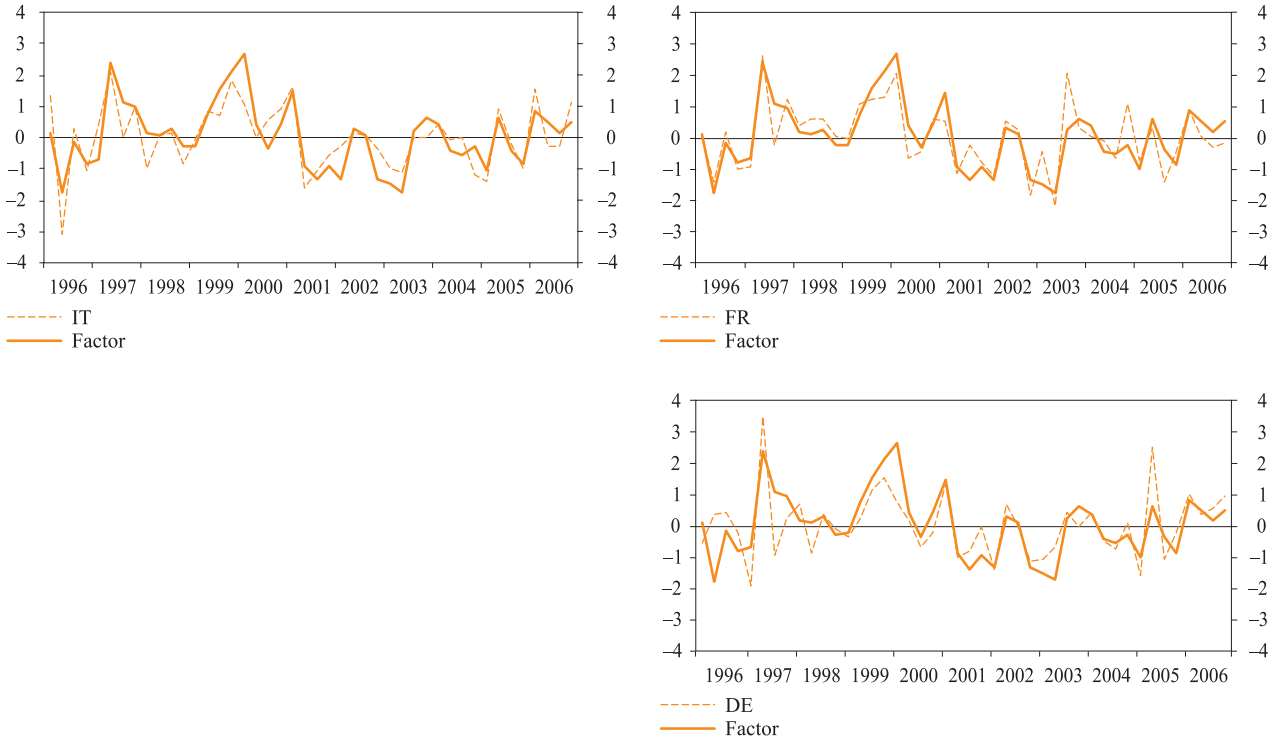
	Chi-square value	df	Probability
$b_{LV} = b_{LT}$	0.201	1	0.654
$b_{LV} = b_{EE}$	0.280	1	0.597
$b_{LT} = b_{EE}$	0.594	1	0.441

Appendix 13
Wald statistics

(two factor model; main euro area countries and Baltic States)

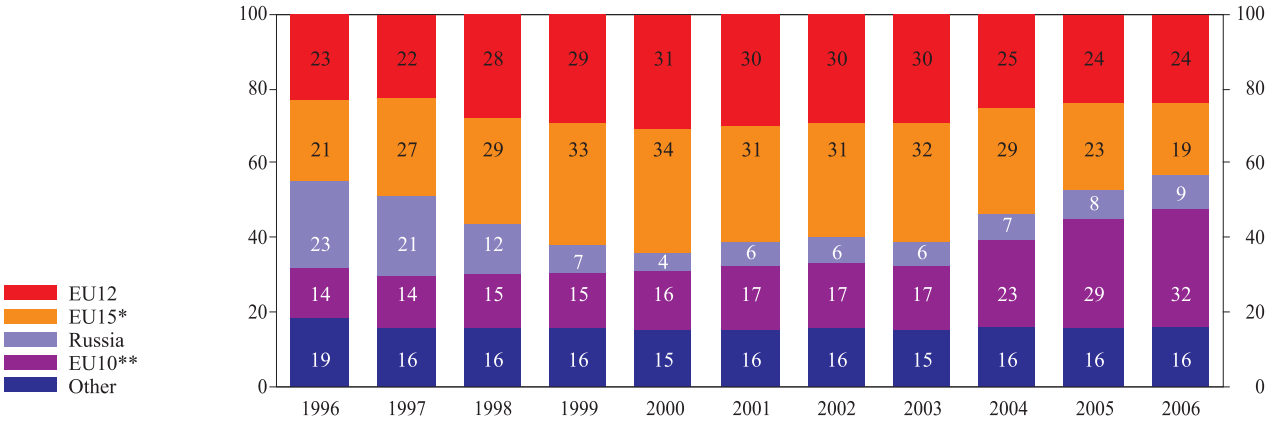
	Chi-square value	df	Probability
$c_{LV} = b_{LV}$	0.021	1	0.885
$c_{EE} = b_{EE}$	0.208	1	0.649
$c_{LV} = c_{EE}$	0.625	1	0.429

Appendix 14
Real standardised GDP growth in Italy, France and Germany: actual data and common factor (two factor model; main euro area countries and Baltic States)



Appendix 15

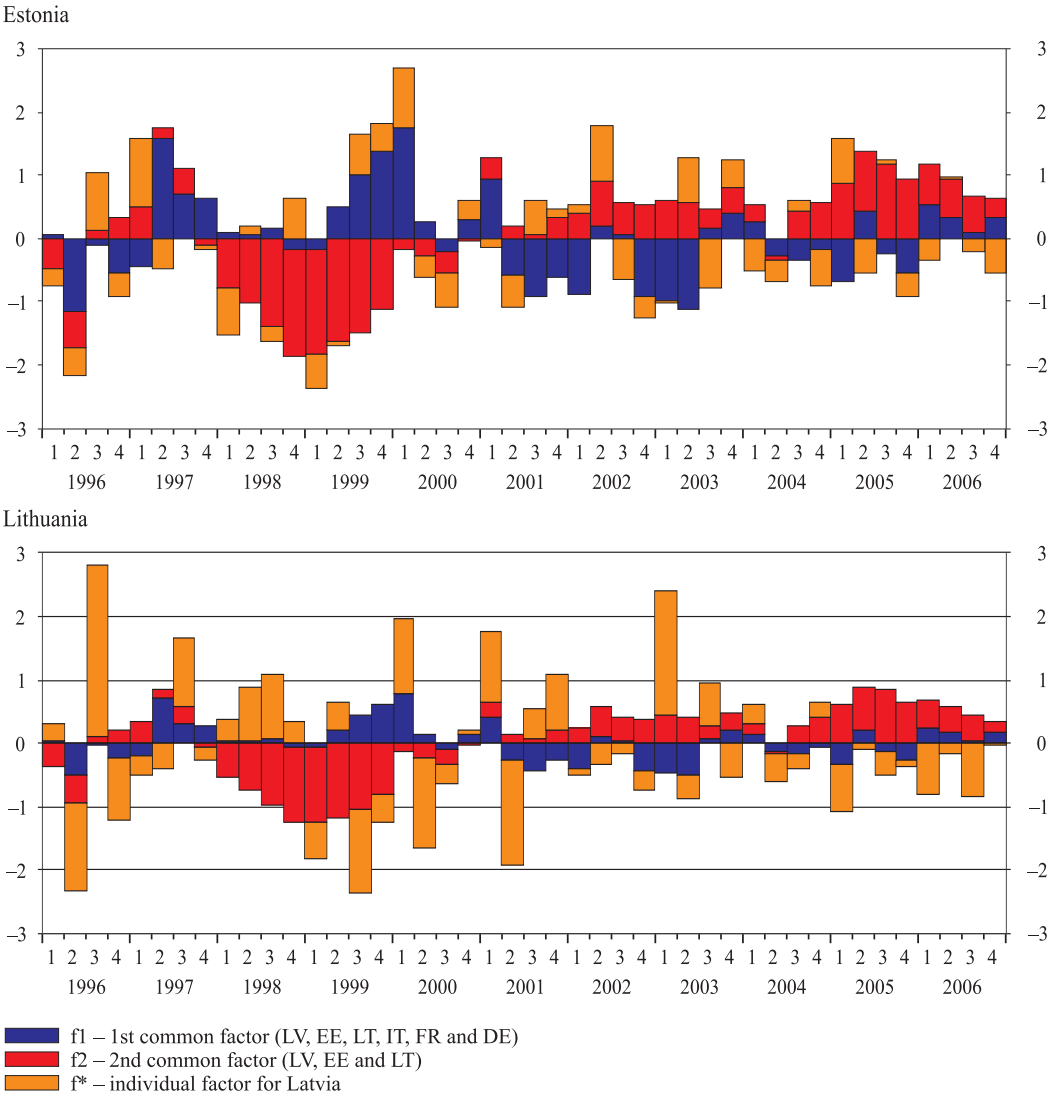
Structure of Latvian exports (%)



* EU15 represents a part of Latvian exports to EU15 not included in EU12.
** Latvian exports to 9 new EU member states (CZ, EE, HU, CY, LT, MT, PL, SI and SK).
Source: CSB of Latvia.

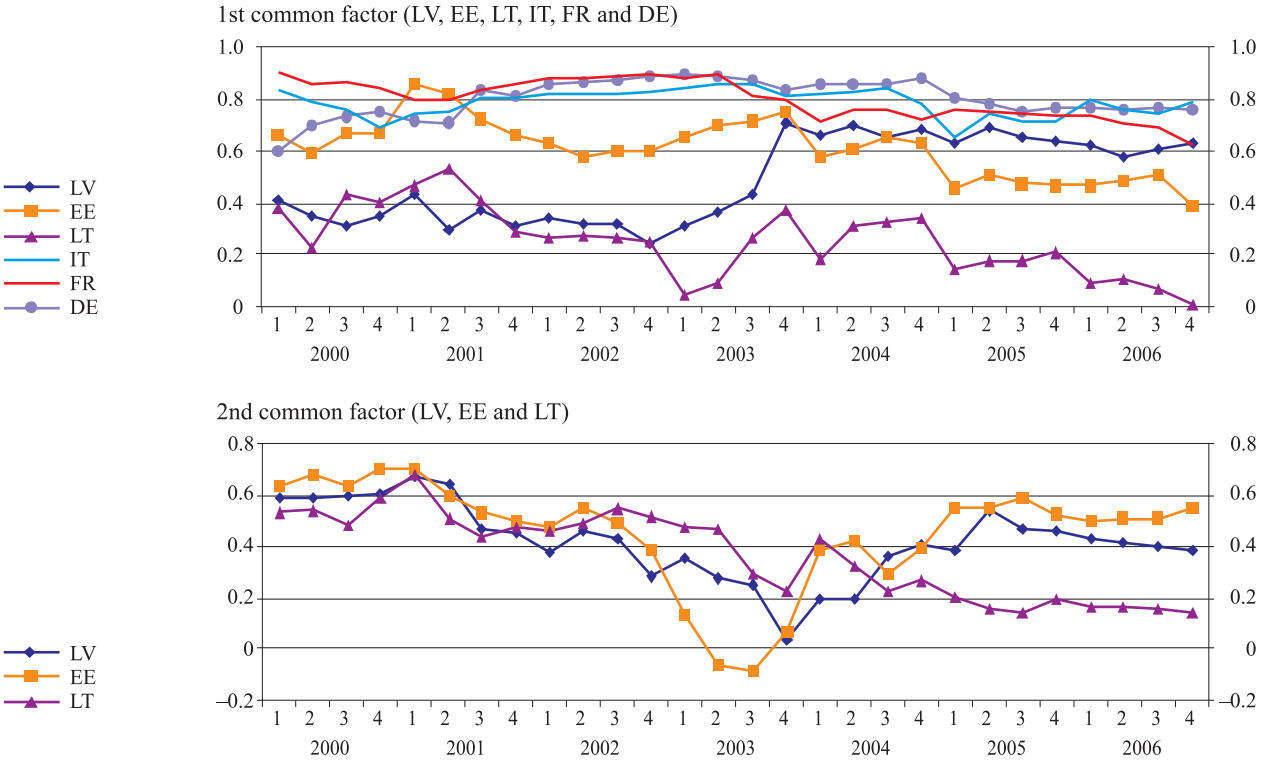
Appendix 16

Contribution of common and individual factor to the dynamics of real standardised GDP growth (two factor model; Estonia and Lithuania)



Appendix 17

Correlation between series of real standardised GDP growth and common factors computed over 4-year moving window (Latvia, Lithuania, Estonia, Italy, France and Germany)



Appendix 18

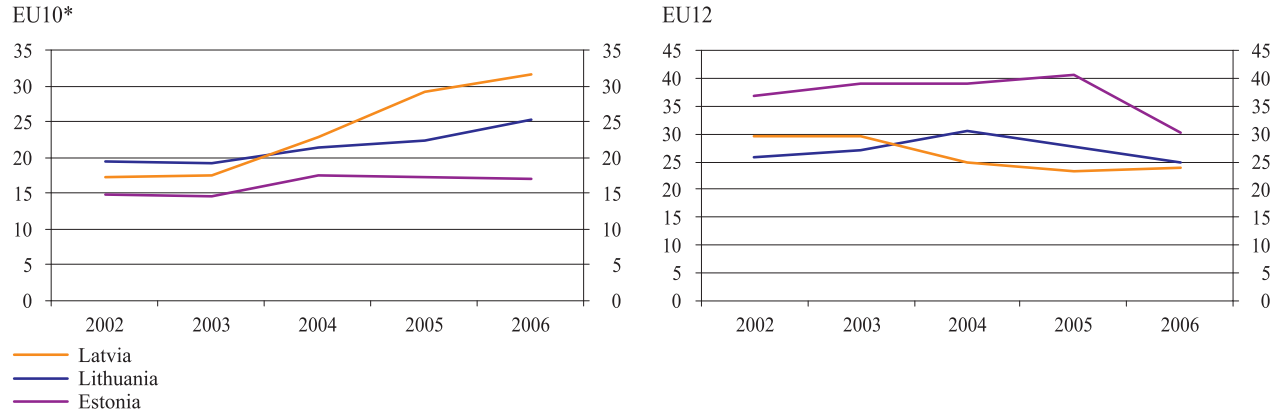
Real annual growth in imports of goods and services (2003–2005)

	Czech Republic	Estonia	Latvia	Lithuania	Hungary	Poland	Slovenia	Slovakia
2003	8.0	10.4	13.1	10.4	9.3	9.3	6.7	7.6
2004	17.9	15.5	16.6	14.9	13.4	15.2	13.3	8.8
2005	5.0	16.3	14.8	17.2	6.8	4.7	6.7	16.6

Source: Eurostat database.

Appendix 19

Share of exports of goods to EU10 and EU12 (%)

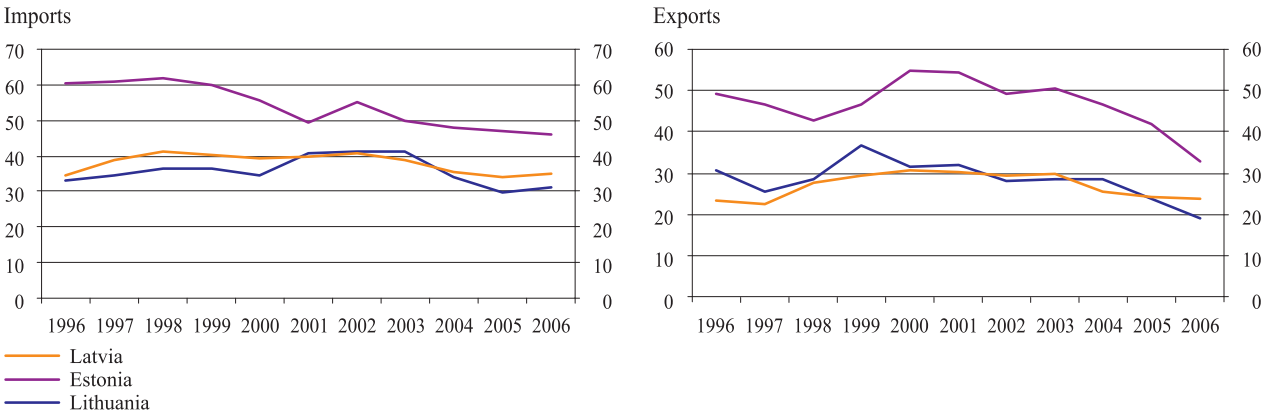


* Exports to 9 new EU Member States.

Source: Comtrade database.

Appendix 20

Share of EU12 in total exports and imports of Baltic countries (%)



Sources: CSB of Latvia, Eurostat database (Lithuania, Estonia).

Appendix 21

Wald statistics

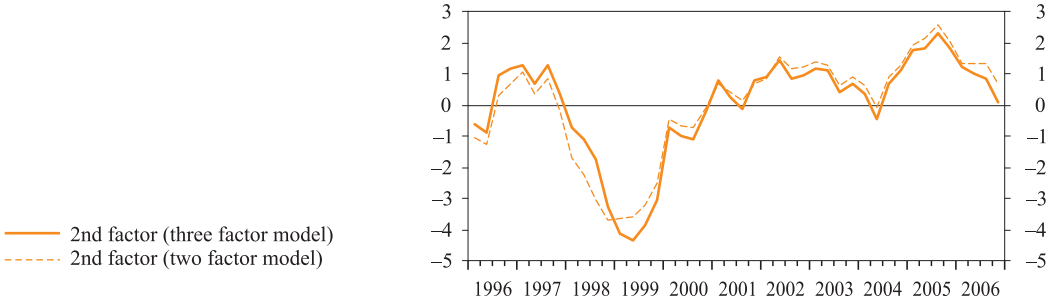
(three factor model; main euro area countries, Baltic States and Russia)

	Chi-square value	df	Probability
$c_{LV} = c_{LT} = c_{EE}$	1.231	2	0.541
$bl_{LV} = bl_{EE} = bl_{LT}$	0.116	2	0.943
$c_{LV} = bl_{LV}$	0.021	1	0.884
$c_{EE} = bl_{EE}$	0.169	1	0.681
$c_{LT} = bl_{LT}$	0.015	1	0.902

Appendix 22

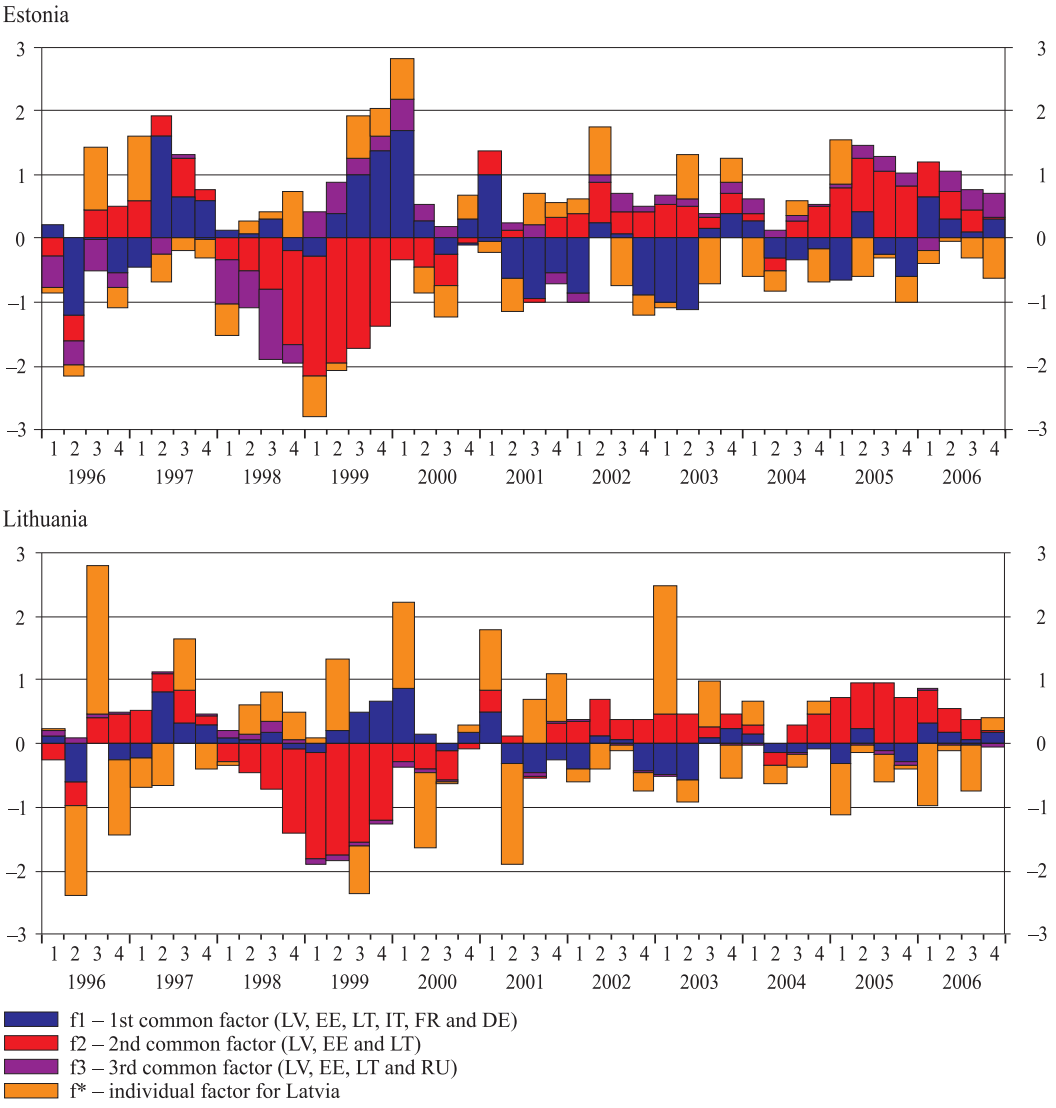
Comparison of common factors for real standardised GDP growth in Baltic States obtained from two and three factor models

(with and without specific factor for Russia; Baltic States, main euro area countries and Russia)



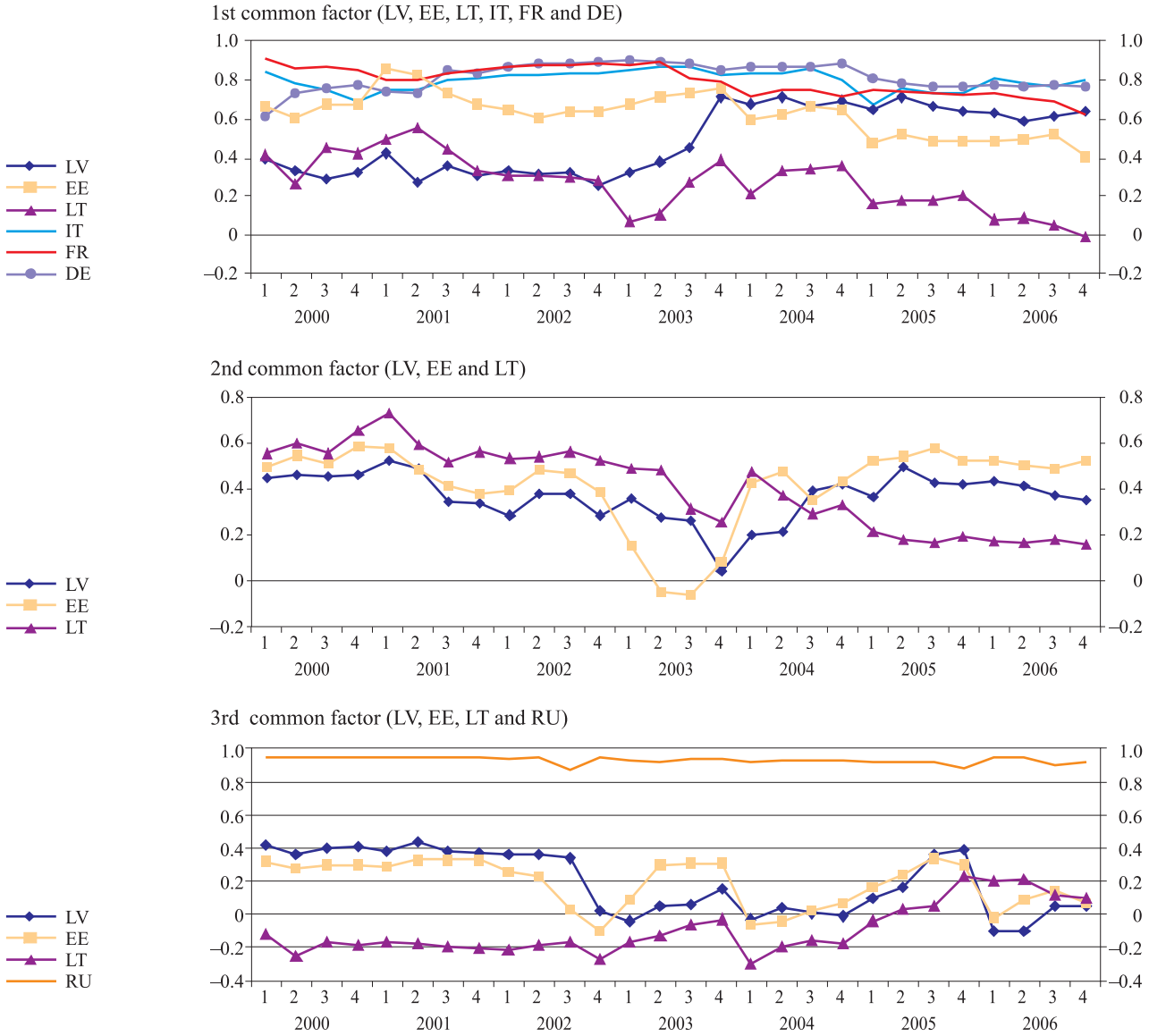
Appendix 23

Contribution of common and individual factors to dynamics of real standardised GDP growth (three factor model)



Appendix 24

Correlation between series of real standardised GDP growth and common factors computed over 4-year moving window (Baltic States, main EA countries and Russia)



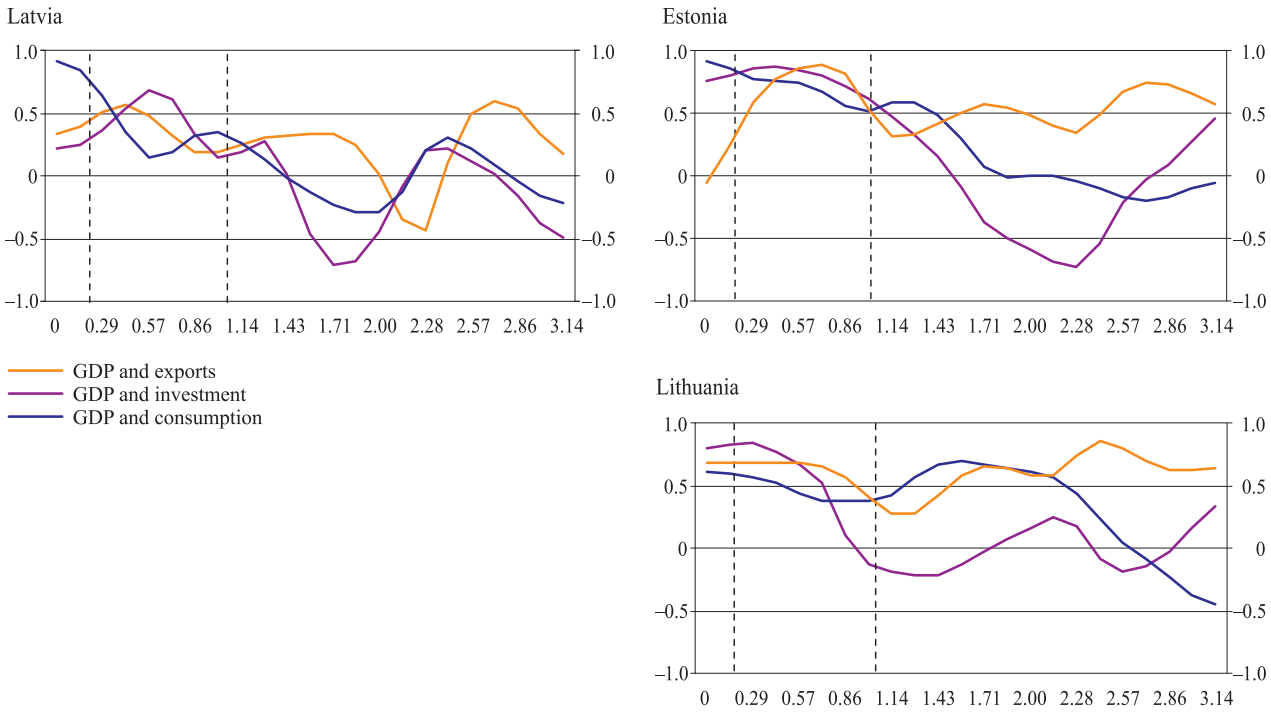
Appendix 25

Pairwise Granger Causality tests with 2 lags

Null Hypothesis	*F*-Statistic	Prob.
Common factor for real investment does not Granger cause common factor for real standardised GDP growth	0.637	0.534
Common factor for real standardised GDP growth does not Granger cause common factor for real investment	3.598	0.037

Appendix 26

Dynamic correlation of real standardised GDP with its components* for frequencies $\omega \in [0, \pi]$



Low frequency band $[0, \pi/16]$ corresponds to cycles with a period longer than 8 years.
High frequency band $[\pi/16, \pi/3]$ corresponds to cycles with a period between 1.5 and 8 years.
Frequency band $[\pi/3, \pi]$ corresponds to cycles with a period less than 1.5 years.
* dynamic correlation between growth series of GDP and investment is calculated for GDP series with one lag.

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