Can policy improve liquidity during a financial crisis?

Ivo Karilaid, Tõnn Talpsepp¹

Abstract

This paper empirically examines the development and determinants of the liquidity position in the financial sector during the recent financial crisis in the Baltic-Scandinavian region. We look at fiscal and monetary policy implications of liquidity problems arising in the crisis. The results are consistent with theoretical predictions for a small open economy with the expected sign of changes and developments in common economic indicators. Changes (and the speed of changes) in interest rates, GDP and money supply have occurred relatively rapidly, meaning that the rising area of the LM-curve has been shorter than theory would predict. Market reactions took place quickly and simultaneously – there was no time for slow restructuring, so that liquidity needs were higher than usual.

Keywords: financial crisis, policy implications, liquidity position, capital flows

JEL classification: G01, G21

1. Introduction and background

The economies of the Baltic States have been amongst the biggest decliners in Europe as well as in the world during the financial crisis that started in 2007. The crisis has had a distressing effect on these small and open economies, while liquidity problems on the world’s financial markets and especially in the region have worsened the situation even further. A number of papers draw parallels among previous crises and the current crisis as well as finding causes for the crisis. But the aspect of disappearing liquidity which causes further problems for whole countries and whether policy measures can improve the situation has so far gained little attention during a time when we can still only talk about an ex-ante view of the current crisis.

The purpose of this study is to explain how the capital market situation and the relative structure of financial companies’ assets (money supply) are related to changes in main economic indicators. Thus the paper provides an ex-ante analysis of liquidity problems during the recent financial crisis and the preceding period. The research is related to theoretical

¹ Tallinn School of Economics and Business Administration (TSEBA) at Tallinn University of Technology, Akadeemia tee 3, 11712 Tallinn, Estonia, e-mail: ivo.karilaid@tseba.ttu.ee, tonn.talpsepp@ttu.ee
examination of the IS-LM model on specific areas\textsuperscript{2} of the LM-curve, sequence of changes and lengths of phases of the curve. All of that has an impact on rational decisions of capital market transactions, resulting in the money market moving to the next theoretical equilibrium point. Theoretical sources of the hypothesis are supported by the Law of Say and the Law of Verdon.

One year after publishing the theory of Keynes, John Hicks wrote an article \textit{Mr. Keynes and Classics: Suggested Interpretation}\textsuperscript{3} in which he presented a simplified conclusion of Keynes's work. After elaboration by Alvin Hansen\textsuperscript{4} and other authors, this became the model of Hicks (IS-LM model), which in 1950 won popularity as “Keynesian” economic theory. Like any other model it is also a simplified version of describing processes in the real economy. The reason why this model is still used nowadays is because it is simple (Brown, 1997). The main advantage may also lie in the fact that the model includes one of the basic corner-stones of the economy, such as money (in this case money as a stock variable, not income as a flow variable), which can be determined when referring to the time of research.

Additionally the term “stock regulating process”\textsuperscript{5} is related with the theory of Keynes and the Law of Say, explaining how the market economy can head lower than full employment equilibrium despite the fact that all production will be bought (Brown, 1997). For developing the stock regulating process, savings and investments should be used. These by nature are also stocks and can be taken as stock variables.

Under conditions of depression, economy can fall into the liquidity trap, which is the Keynes area of the LM-curve when the curve is quite horizontal. The opposite situation is the vertical area of the LM-curve, which occurs in a booming economy when all money is used for business transactions. In between there should be a more realistic area of the LM-curve when the curve is rising, meaning that money is divided between bank accounts and business transactions. Theoretically, shifts from the vertical area to the horizontal area should take some time but empirical data show that the time for shifts can be significantly shorter during a crisis.

Theoretical models illustrate how important it is to manage stocks in the economy and how money is a standard for measuring stocks with its characteristics like interest rates and volume. Currently we still cannot say that the financial and economic crisis that spread all over the world has ended. Thus, this paper acts as an \textit{ex ante} study of the consequences of financial crisis for the money market, more precisely liquidity issues arising and policy implications of problems faced in the crisis.

\textsuperscript{2} The LM-curve is probably steady and rising but it is efficient to treat three areas separately. Under conditions of deep depression, the economy can fall into a liquidity trap - this is Keynes's area and the curve is quite horizontal. In the case of fast expansion and high interest rates, all money will be used for business transactions and the LM-curve will become quite vertical - this is called the classical area. The most important is a rising LM-curve when money is used for business transactions and money is also on speculative accounts (Gordon, 1994).

\textsuperscript{3} John Hicks, Mr. Keynes and the Classics: Suggested Interpretation, Econometria, 5 (April 1997), pp. 147-159.


\textsuperscript{5} The stock regulating process takes place in the following manner. When companies are producing more than they sell, then stock will accumulate. When stock increases over the desired level and there is nowhere to realize it then an enterprise will stop activities in that direction and will fire employees related to that action (inputs). In the following period, an enterprise can realize at the expense of previously accumulated stock more than it produces in that period. If this process continues, inputs should be increased for the next period to increase production. There is an equilibrium when entrepreneurs realize just as much as they produce and the stock remains relatively the same.
We approach the problem from a LM-curve based theoretical background and take an indirect approach by studying economic indicators to see the shift between the booming area in the LM-curve and the crisis area. We study how the level of overnight interest rates has fluctuated in the Baltic countries (Estonia, Latvia and Lithuania) studied as well as in the Scandinavian countries (Finland, Sweden and Denmark) studied. In the LM-curve framework, interest rates are more easily observable than demand and supply quantities at different interest rate levels. Thus, data availability problems dictate our indirect approach by looking at different relevant economic indicators and drawing mostly qualitatively explained conclusions from the time series and cross sectional differences of economic indicators within the sample used.

The sample has been chosen since it enables a simultaneous look at three small open economies (namely the Baltic States) to see whether and how much the policy makers of those countries can influence the situation by providing and improving the overall liquidity point of view. At the same time the Baltic States are greatly influenced by European Union countries, as data show (see e.g. Table 1 and Table 2) especially by neighboring Scandinavian countries. In the framework of liquidity and the money market, the influence is evident due to the fact that most of the major banks in the Baltic States are owned by financial institutions of Scandinavian origin.

Although our focus is on the money market, we cannot neglect the importance of other economic indicators. From the policy maker’s perspective, we have to look at as complete an economic picture as possible. The money market as a fundamental part of the capital market is influential in investment decisions and gives one of the key indications about the discount rate. The most widely used value bases in management models in investment decisions are NPV (Net Present Value), PI (Profitability Index), EP (Economic Profit), EVA™ (Economic Value Added) etc. These models are related to the basis of discounted future cash flows, which means that the value depends directly on the discount rate. Accordingly there is a fundamental influence on investment decisions and the assets structure of companies.

As to studying the history of financial crises, typical characteristics are present in the economy that precede a crisis and influence how the economy tends to move out of crisis. Reinhart and Rogoff (2009) study all the financial and economic crises in the world during the period 1890-2008. They find that financial and economic crises tend to be preceded by rapid economic expansion with increasing consumption and booming prices in different real and financial sectors. GDP reaches its largest decline one year after the start of the crisis. Unemployment is regarded as a lagging indicator and starts to decrease during the first or second year of a crisis, not before. There is not a clear trend concerning inflation but depending on the specific broader economic conditions, inflation can still be high during the start of the crisis and start declining thereafter as economic expansion turns into recession. Those main characteristics are also present in the current sample of countries.

Kaminsky and Reinhart (1999) show that usually inflation during a domestic debt crisis is clearly higher compared to an external debt crisis. As currently rising levels of domestic debt were the drivers of pre-crisis economic growth in the Baltic States, a relatively high level of inflation was more expected than would have been the case in external (government) debt problems. Usually a very high co-movement occurs in the share of countries having high inflation and defaulting on their sovereign debt (Reinhart and Rogoff 2009) but currently this
did not concern the Baltic States studied. Otherwise both external and internal debt problems are common causes of crisis.

Experience from past crises (Reinhart and Rogoff 2009) shows that countries experiencing sudden large capital inflows are at high risk of experiencing a debt crisis. This can lead to over borrowing in good times, leaving countries vulnerable during the inevitable downturns. The same happened in the Scandinavian countries (Mai 2008) during the banking crisis of the 1990s which should have been a lesson to bankers in the Baltic-Scandinavian region but reoccurred in the Baltics during the current crisis.

A high probability exists of the current account balance being negative before a crisis as higher consumption and imports tend to overtake exports. This is exactly what happened in the Baltic States. Either by devaluation of the local currency or restructuring the economy and production, exporting goods starts to pick up during a crisis. Thus, weakening the currency or the necessity for devaluation (in the case of pegged currencies) are very common artifacts of economic and financial crises. Thus fears of devaluation of local currencies (worsening the liquidity situation in local markets) in the Baltic States were just expectations based on lessons of past crises.

A number of common policy implications help to avoid the worst outcomes during a crisis. Namely, having a complete picture of government indebtedness is critical. Debt sustainability must be based on plausible scenarios for economic performance and is a must factor in the possibility of sudden stops in capital flows. Inflationary risks to monetary policy frameworks seem to be linked in important ways to levels of domestic debt. Many governments have a temptation to inflate away domestic debt. Using stimulus packages has become widespread during the current crisis but such packages have not been widely used (with some exceptions) during past crises, which makes the success and efficiency of such a stimulus harder to predict.

The remainder of the paper is organized as follows: Section 2 gives a brief overview of the data and methodology used. Section 3 empirically analyses the current crisis in the Baltic and Scandinavian countries based on analysis of the dynamics of a large number of economic indicators and proposes policy measures to soften the emerging negative consequences. Concluding remarks are offered in Section 4.

2. Data and methodology

The study concentrates on the last financial crisis and the preceding period with data used from 1994 to 2009. The sample consists of the three Baltic States (Estonia, Latvia and Lithuania) and three Scandinavian countries (Finland, Sweden and Denmark). The sample has been chosen as it enables a view of how the banking sector of three small open economies is influenced by neighboring more developed countries, which has a clear impact on the inflow of funds to the smaller countries.

Data used in empirical analysis come from two main sources. These are Datastream and International Monetary Fund IFS data collection. We use the latest available data. In the case of
seasonally unadjusted data, we use seasonal adjustment techniques. For better comparability, we use the average exchange rates in situations where comparing the magnitude of the series across countries is necessary. Data on interest rates come from Datastream as well as most economic indicators. Data about reserves, foreign trade and investments, as well as data concerning the assets and liabilities structure of financial institutions come from IFS databank.

We look at the dynamics of the asset structure of the financial sector. By assets we mean financial assets in classical terms. Depository institutions are used because commercial banks are the most important participants in money and capital markets in the Baltic States and the influence of other players in this field is still small (Kein, 1999).

As the paper analyses the situation from the LM curve perspective, data availability dictates the indirect approach used. We look at different relevant economic indicators and draw mostly qualitatively explained conclusions from the time series and cross sectional differences of the economic indicators. We run a number of single regressions to verify the relationship between different economic indicators both within a single country and between the countries viewed. We present a correlation matrix of the results and additionally run cointegration tests to verify the long term relationships between the indicators. The Dickey Fuller test is utilized for testing stationarity of the series and Johansen cointegration tests are run after that. We run cointegration tests both with the original adjusted time series as well as on the first differences of the time series.

3. Empirical study of the crisis

3.1. Interest rates

When studying the interest rate co-movement of Baltic and Scandinavian countries, we can see that the interest rates of Denmark, Sweden and Finland coincide greatly with Euro interest rates. Although Denmark and Sweden have not adopted the Euro, their central banks have lowered their rates in quite a similar manner to the European Central Bank as can be seen from the overnight interest rate (see Appendix A) which closely follows the base rate of the country.

The interest rates of the Baltic States have behaved slightly differently during the crisis. During the period 2000 to 2007 we can see more volatility, especially in Latvian and Lithuanian rates. A remarkable decrease occurred in overnight rates after the end of the 1997-1999 crisis. As the currencies of all three Baltic States are principally pegged to the Euro, the central banks of these countries do not have the means to directly influence the rate by money supply. Basically, policy makers cannot influence liquidity on that level. Still, the implications of the recent model of Brunnermeier and Pedersen (2009) suggest that central banks can help to mitigate market liquidity problems by easing funding or margin requirements. Even public statements that extra funding will be provided during liquidity dry-ups could help.

The dramatic increase (and also decoupling from Euro rates) of the overnight and also longer term interest rates in the Baltics clearly illustrates a situation where central banks are unable
to provide expansive measures, while local markets are more influenced by outflow of foreign investment, which happened after the beginning of 2007. The speed in the change of interest rates was dramatic. For example it took 20 days in September 1999 for the Latvian overnight rate to rise from 3.5% to over 8% and less than 10 days in March 2007 to rise from around 2% to 8%. Such quick changes do not allow the economy to adjust to changes in interest rates and shrinking money supply.

Appendix B illustrates the situation further. When Scandinavian countries as well as the Euro area have on average been able to continue to hold a more or less stable positive trend in money supply even after GDP levels started to deteriorate, the same has not happened in the Baltics. Especially Latvia and Lithuania have faced an even more abrupt decline in money supply than the dramatic fall in GDP figures. At least until the second half of 2009, Estonia did a little better.

A classic policy makers’ approach in the case of an economic downturn is to start cutting interest rates to stimulate the economy. Another negative consequence is loss of confidence in the financial system during a crisis which, among various negative effects, can also induce bank-runs. Currently, cutting interest rates is exactly what has happened in the Euro area as well as in Sweden and Denmark, starting from 2008. Interest rates have dropped significantly moving in the same direction as falling GDP, which we use as a primary proxy for assessing the state of the economy. The same has not been possible in Estonia, Latvia and Lithuania. Interest rates in Estonia, Latvia and Lithuania have moved in the opposite direction due to shrinking money supply, loss of confidence and rising devaluation expectations. Thus it should not be too surprising that in addition to a shrinking economy, decreased money supply and increased interest rates have worsened the situation even further.

Although interest rates have not been directly controllable by policy makers in the Baltics, the high level of interest rates has partly also been caused by lack of confidence of market participants in the perseverance of currency pegs and the banking system. It could be argued that injecting confidence in market participants as well as preserving a sound economic climate (we mean conditions under which the central government is able to control the level of external public debt and its expenditure) could help to smooth the magnitude of negative currency speculation. On the other hand, although stimulus packages have not been too widely used during past crises in the world (Reinhart and Rogoff, 2009) (with the not too successful exception of Japan), decreased government expenditure and lack of external financing options will decrease money supply. Thus, policy makers in pegged currency systems can have expansive means on the capital markets basically only when borrowing and spending have been conservative during good times, so that external financing and assurance of stability remain possible during a crisis when the confidence of financial markets has eroded. In a crisis, outflow of funds occurs not only from small emerging economies but also from most other countries.

We also look at spreads between short-term (overnight as well as 6-month) interest rates and long-term interest rates (we use 10-year government bonds for that). Tightening of spreads

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6 Allen and Gale (1998) study the optimality of choice regulators and central banks have to make when dealing with the risks associated with crises to avoid bank-runs.
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during a crisis epicenter can be regarded as an expected result as short-term interest rates rise higher than long term government bond yields in all countries in the study. Spreads between short-term and long-term yields started to tighten in 2004 and turned negative by the first half of 2007. The adjustment in spreads back to the levels of 2004 was very rapid and took less than four months starting from the end of September 2008 in the Scandinavian countries\(^7\). Thus changes in long-term interest rates are slightly smoother than in overnight rates. But compared to 10-year rates, short-term interest rates have a clearly stronger impact on current liquidity positions.

3.2. Inflation and real interest rates

By their inflationary levels, Estonia and Lithuania have been in a better position than Latvia. Latvia had not seen lower than 5% inflation (we look at CPI) since the beginning of 2004 until the over 10% levels of 2007 and 2008 dropped below 5% in the second quarter of 2009 and have been decreasing since. Inflation also rose above the 10% level in Estonia and Lithuania in 2008. Before that it stayed around the 5% level and was increasing since 2007. Pre-crisis years clearly indicate that the Baltics were facing a very high inflationary environment, which in turn encouraged investing (and seemingly also for households to continue spending) as much as possible and real interest rates were negative due to high inflation. In the light of providing liquidity, the pre-crisis years attracted foreign inflows of money. When soaring interest rates and the inflationary environment turned into deflationary, this discouraged investment as real interest rates were also expected to rise in the light of diminishing inflation (by the third quarter of 2009, only Estonia had shown negative CPI). Real interest rates also increased because the situation of shrinking money supply and devaluation worries encouraged commercial banks to keep nominal interest rates high on deposits. Such an effect caused a situation where holding money on deposit with minimum risk was rewarded by high real interest rates and investing funds was discouraged by higher risk of investment in a shrinking economy. This caused a situation where more funds were waiting on the sidelines (read: were lying in deposit accounts) than invested in an economy facing outflow of foreign funds at the same time.

Table 1. Correlation between changes in country GDP in EUR from 2000-2009.

<table>
<thead>
<tr>
<th></th>
<th>Denmark</th>
<th>Estonia</th>
<th>Euro Area</th>
<th>Finland</th>
<th>Latvia</th>
<th>Lithuania</th>
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<tr>
<td>Estonia</td>
<td>0.880</td>
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<td>Euro Area</td>
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<td>0.835</td>
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<td>Finland</td>
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<td>0.896</td>
<td>0.911</td>
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<td>0.810</td>
<td>0.906</td>
<td>0.867</td>
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<td>0.859</td>
<td>0.822</td>
<td>0.855</td>
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<tr>
<td>Sweden</td>
<td>0.804</td>
<td>0.794</td>
<td>0.666</td>
<td>0.838</td>
<td>0.707</td>
<td>0.746</td>
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</table>

\(^7\) Overnight interest rates stayed higher than long-term interest rates till the end of 2009 in Latvia, which was caused by devaluation fears.
3.3. Economic growth

We look at GDP as the main indicator of economic well-being. To make the figures comparable, we calculate GDP for all countries in Euro and adjust the time series for seasonality. As the Swedish kronor has been the single most volatile currency against the Euro and has weakened nearly 20% against the Euro since the first half of 2008, this puts Swedish economic performance in a darker light than would be measured in local currency.

In Table 1 we present the correlation between the GDP (measured in EUR) growth rates of the countries studied since 2000. Viewing longer periods would make the correlation between the Baltic States higher and using local currencies would increase the correlation between Sweden and the rest of the sample. We would assume significant influence by the Scandinavian countries on the Baltic States, as much of the financial sector in the Baltics is under the control or direct influence of banks of Scandinavian origin.

Indeed, the correlation of GDP growth rates is quite significant in all cases. Finland has a nearly 0.9 correlation with all three Baltic States, the highest figure with Estonia. That is, considering their geographical proximity, an expected result. Sweden again has a higher correlation with its neighboring countries and a slightly lower correlation with Latvia and Lithuania. Although we cannot show causality in those relationships, all countries do seem to have a higher correlation within the Baltic Sea region than with the average Euro area.

When studying the starting points of the economic downturn in the area, we look at the time series of GDP in both Euro and local currency. Although Sweden showed quite a stable GDP growth in the fourth quarter of 2007 in local currency, the weakening of the kronor decreased growth to only 0.5% when measured in Euro. All other countries (with a minor exception of Denmark) were still experiencing a strong growth phase (especially Latvia and Lithuania) during that time. Already the next quarter meant a surprising turn into negative territory for Estonia and Denmark, with Latvia following a quarter later and all other countries in the fourth quarter of 2008. This effectively turned all hopes of a soft landing for the economy into an ineluctable global crisis that had already suffered significant setbacks earlier in autumn 2008 with plummeting financial markets and an unseen surge of volatility after Lehman Brothers was forced to declare bankruptcy.

As Sweden is the largest economy in the sample viewed, one might expect a greater influence from there on smaller neighboring countries. We can qualitatively argue that the influence of Swedish financial sector worries was the most evident in Estonia and Latvia. Although Swedish GDP growth stayed quite stable until the fourth quarter of 2008 when looking at the figures in kronor, Sweden was - along with Estonia - the leading country in slowing and turning negative when considering the framework of the EU and looking at GDP figures in Euro. We can also see (Appendix A) that the stock market (which is considered one of the main leading indicators) started to fall first in Estonia and Sweden.

Correlations within countries (see Table 2) between money supply (either M2 or M3) and GDP are strong, ranging between 0.82 for Latvia (0.84 for Finland) and 0.93 for Estonia (0.91 for Sweden). Especially for the Baltic countries, cointegration test results mostly confirm the correlation findings. The correlation between money supply and interest rates has an expected
Table 2. Correlation and cointegration matrix of Euro zone, Estonian, Latvian, Lithuanian, Finnish, Swedish and Danish GDP, money supply (M2 or M3) and average overnight interest rates (i) for the period Q1 1995 to Q3 2009. The table presents correlations in the lower right part of the matrix and results of cointegration tests in the upper right part of the matrix. Cointegration results are presented if either series were found to be cointegrated (+) or not (-). Cointegration test results are presented both for the first difference of the series (the first + or -) as well as the original seasonally adjusted series (the second + or -).

<table>
<thead>
<tr>
<th>Unit root</th>
<th>EUR M2</th>
<th>EUR i</th>
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negative sign (except for Latvia - data problems connected with the availability of money supply data) and falls in the range from -0.22 to -0.52 but has very clear cointegration test results confirming the relationship.

3.4. Reserves, investment position and foreign trade

The current crisis situation is well reflected also in the international reserves which reflect the monetary policy of central banks. For example the reserves of Denmark more than doubled in less than six months starting from Q3 2008 and jumped by 40% in June 2009 for Sweden. The changes have not been so drastic in Finland and in the Baltics with pegged currencies and limited ability to enforce monetary policy, but growing reserves are evident for the whole sample. When comparing international reserves to total depository financial institution assets, the changes in reserves are not as abrupt but can still indicate that piling up reserves had negative effects on liquidity (and money supply) in the economy. In Q2 2009 reserves amounted to approximately 6%, 4% and 2% of depository assets in Denmark, Sweden and Finland respectively, but 12%, 9% and 15% in Estonia, Latvia and Lithuania which have to hold larger reserves due to pegged currencies. Maintaining the reserve level turned out to be a challenge for Latvia due to outflow of foreign funds (Transition Report 2009).

Studying the investment position of these countries shows clearly in all cases investments starting to pull out from foreign countries (see Appendix C). This is similar for both direct and portfolio investments when domestic interest rates soar and money supply starts to decline along with a shrinking economy. The Scandinavian countries have a larger amount of foreign portfolio investments, which should be a clear indicator of more developed financial markets.

Figure 1. Boosting international reserves during a crisis. The left vertical axis presents figures in billion SDR for Scandinavian countries and the right vertical axis in billion SDR for the Baltic States.
The Baltic States tend to have less portfolio investments and are dominated by a very large share of direct investment.

When comparing Estonia, Latvia and Lithuania amongst each other, we can see that although the Estonian economy is the smallest of these in absolute numbers, it has attracted the highest number of both direct and portfolio investments. In the case of an economic downturn, those investments start to seek a way out. In the case of disappearing liquidity, this is not an easy task and starts to greatly affect the domestic economy. Estonia is the country most affected by outflow of investments as its dependence on investment is the greatest (highest share of foreign investment per GDP in local economy).

We can see a clear correlation between falling stock market prices and decreased value and outflow of foreign portfolio investments, which indicates that stock market prices are greatly influenced by foreign investors originating from and within the Scandinavian region. In the sample, the correlation is the strongest for Finland and Estonia. Unfortunately we do not have data available for Sweden, which probably has the biggest influence on neighboring countries’ stock markets. For Euro area and Scandinavian countries, the drop in foreign portfolio investments has been larger than for direct investments. At the same time they have also pulled out (or lost value in) their own portfolio investments abroad. As the Baltic States are greatly influenced by those countries, plummeting stock indexes and lending by foreign owned banks almost at a standstill should not be a big surprise in retrospect.

Currently we can only qualitatively argue that the drop in direct foreign investment in the Baltic economies can have a longer term negative effect. Generally, portfolio investments are more mobile, meaning that they can move in and out of the economy faster than direct investments. The latest available data shows some promising signs for the Baltics as both Estonia and Latvia seem to be showing the first signs of stabilizing the level of foreign direct investment in the economy. Due to a high correlation between the Baltic States, Lithuania can be expected to follow their lead. The amount of investment abroad is not very high for any of the Baltic States, which can be one reason why foreign investments abroad have not lost as much relative to Scandinavian countries. On the other hand, Scandinavian countries have been donors for inflow of investments into the Baltic States and the falling Baltic economies have negatively affected their investment values and decisions. Considering the size and correlation of the Scandinavian economies viewed, drops in foreign investment are probably affected by pulling out portfolio investments from each other’s economies and the Baltic economies are negatively affected from the outflow of funds initiated by the Scandinavian side.

The inflow of funds to all Baltic States had more than tripled from 2004 to the end of 2007. As presented in the anatomy of crisis section of the paper, such a sudden large inflow of funds can lead to borrowing more than necessary, high inflation and thus can often cause trouble later when the inflow stops or reverses. This is one area where policy makers could theoreti-

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8 See Masso, Varblane, Vahter (2008) and Vahter and Masso (2005) for a detailed study of spillover effects of inward and outward FDI.

9 Estonia has a clearly higher level of both foreign direct investment and foreign portfolio investments abroad to GDP compared with Latvia and Lithuania. The level of outward FDI to GDP for Estonia is approaching the level of developed Scandinavian countries but is still lower and not with comparable magnitude in absolute terms.
cally have imposed regulative means to discourage domestic borrowing from a certain level by higher capital requirements. As inflow of foreign investments during good times helps to boost the economy, motivation for policy makers to discourage such inflow is extremely low, resulting in higher volatility in the economy.

As expected, we can see an increasing current account deficit in all three Baltic States during times of booming economy (see Appendix D). At the same time, the capital account stayed positive. Thus the Baltic States have followed a more classical and expected road to crisis than the Scandinavian countries, where changes in current or capital account have not been too noticeable. Both export and import have moved in sync with GDP and faced significant drops in 2008. A clearly larger drop in imports compared to exports in the Baltics has been very harsh but had some sobering effects on economies that obtained their previous growth from consumer expenditure. The positive side of such a drop in imports is that the trade balance is starting to turn positive, which is necessary to restart the economy, as past crises have shown.

### 3.5. Government and household expenditure and investment

We look at growth in gross fixed capital formation (GFCF), household and government expenditure compared to GDP growth, which show a high correlation with each other.\(^{10}\) We run a number of single linear regressions with growth rates of GDP as the right hand side variable and growth rates of expenditure or investments as the left hand side variable to measure the sensitivity (or slope coefficient beta) of those indicators to changes of GDP. GFCF both increases and decreases with a magnitude larger than GDP (beta around 2 for all countries).

As could be expected, government expenditure is more rigid and does not adjust to GDP decline as easily as for GDP growth. Government expenditure has a low correlation with GDP growth for Scandinavian countries and Estonia but is slightly higher for Latvia (0.37 correlation coefficient) and Lithuania (0.21). Those two countries also have a higher beta for government expenditure reaching near and over 0.7, which still means that over the period viewed (1996-2009) government expenditure was not much influenced by the current period of economic growth. Government expenditure is one of the few main economic levers that can be directly affected by policy makers’ decisions.

One of the main problems that should have been an early warning sign for the Baltic States is that starting from 2005 and 2006, household expenditure started to increase much more quickly than GDP. For previous periods throughout the period viewed, such a problem did not exist, as also for Scandinavian countries. For all countries, the correlation between household expenditure and GDP has been around 0.8 for the period viewed but for the Baltics household expenditure has had a beta around and over 1 (it is less than 0.8 for Scandinavian countries) when compared to GDP growth. High domestic household expenditure growth in the Baltics was also one of the main sources of inflation during the pre crisis period.

\(^{10}\) Data and figures are available upon request.
3.6. Depository institutions’ balance sheet structure

We look at how depository institutions’ assets and liabilities structure has changed during the period under analysis. Well functioning financial institutions is one of the most critical aspects for providing liquidity during a crisis, as disruptions in the banking system can have a harsh effect on aggregate economic activity (see e.g. Bernanke 1983). As expected, Figure 2 shows overall growth in the assets of banks to the second half of 2008 when the negative effects had not reached the balance sheets of the banking system. The Baltics were clearly leading private sector credit growth among the emerging economies in the world from 2001-2007 (Brixiova, Vartia, Wörgötter 2010) which had a clear positive effect on the size of commercial banks’ balance sheets. After that point the Baltic States and Sweden (which has the most exposed risks towards the Baltics) faced a slight drop in assets, which is at least partly explained by loan losses.

The trend in bank asset structure in the Baltics (see Appendix F), especially in Latvia and Lithuania, is that claims on foreigners are decreasing and domestic exposure is rapidly grow-

**Figure 2.** Growth of assets of depository financial institutions. The left vertical axis presents figures for Scandinavian countries and the right vertical axis for the Baltic States. Estonian data start from 2004 and have an index starting point of 1.7 to make it comparable with the other Baltic States.
ing. In that sense Denmark and Finland (see Appendix E) have been at quite a stable level but foreign exposure of Swedish banks has been clearly growing since 2004. At least part of that foreign exposure growth can be explained by financing Swedish owned banks in the Baltic States. Claims on the central government have become less and less important in time.

The liabilities side of bank balance sheets clearly reflects the Baltic States’ reliance on inflow of foreign funds. Around 40% of liabilities in Estonia and Lithuania and 50% in Latvia are to nonresidents. The majority of these are loans from parent companies to local banks. In case of economic trouble, such funds can start fleeing the country, making the liquidity position even harder, which has been especially true for Latvia (see also Transition Report, 2009). Although the liabilities structure does not show a very clear decrease in liabilities to nonresidents during the crisis, we can still observe a slightly shrinking share of foreign money, on top of which assets and liabilities started to decrease in general. This is empirical evidence that foreign money is flowing out more quickly than the decrease in assets.

A large share of liabilities to foreigners distorts the overall liquidity picture in the Baltics. Leaving foreign liabilities aside, we can see a slight piling up of liquid assets on deposits searching refuge from the real economy and securities investments which have been losing value since the beginning of the crisis. Such an effect is the most evident for Sweden, Finland and Estonia and also supports the picture presented about international reserves.

Another interesting aspect is liabilities to central government. This does not play an important role in Estonia but has clearly increased in the other Baltic States and Denmark. This would be one place where government aid packaged to banks would be reflected. It is slightly surprising not to see any noticeable changes here for Sweden in the data used.

4. Conclusions

Empirical data show that changes in interest rates, GDP and money supply occurred relatively rapidly and simultaneously in all countries of the Baltic-Scandinavian region but especially in Estonia and Latvia, so that it did not give economies much time to adjust. That caused a situation where interest rates in the more fragile Baltic economies decoupled from the Euro and Scandinavian area and soared almost to previous crisis heights. This clearly illustrates a situation where central banks of open small economies are unable to provide expansive measures and local markets are more influenced by outflow of foreign investments, which started happening after the beginning of 2007.

The correlation of GDP growth rates is quite significant in all cases, which is positively connected with geographic proximity. All countries do seem to have a higher correlation with the Baltic Sea region than with the average Euro area. Thus, financial sector worries - especially in Sweden, Estonia and Latvia - closely influenced each other as Sweden and Estonia were the leading countries with slowing and negative economic growth. High correlation of GDP and money supply meant that along with soaring interest rates, liquidity on the markets shrank significantly. After the inflow of investments to all three Baltic States had more than tripled from 2004 to the end of 2007, the outflow of funds initiated by the Scandinavian side (seen from the data about investment position and consolidated balance sheets of depository
institutions) and piling up of international reserves worsened the situation even further in the Baltics.

Experience from previous crises suggests that having a complete picture of government indebtedness is critical and inflating away domestic debt might not be a good idea. In the Baltic States, the central banks do not have clear monetary policy means to influence the money supply by interest rates but even public statements on providing extra funding when necessary could help to inject confidence in the financial markets during liquidity crises but only if necessary buffers exist. Buffers could be achieved by government controlling the level of external public debt as well as its expenditure during good times. Policy makers in pegged currency systems such as the Baltic States can positively affect the liquidity position basically only when borrowing and spending has been conservative enough during growth in the economy. That could improve the chances for external financing during a crisis. Operating in a small and open economy can make policy makers’ use of levers less effective due to high dependence on and correlation with larger neighboring economies.

As the economies of the region studied are still under stressed conditions, the current study reflects only an ex ante view. This could be complemented by a more thorough ex-post study that could take into consideration the whole economic cycle.

References


Appendix A. Interest rates, GDP, stock market and local currency.
The bottom pane of the charts presents figures for the Baltic States and the upper pane for the Scandinavian countries for overnight interest rates, GDP and stock market. GDP is presented in quarterly constant prices in million EUR. Latvian currency is presented in 10xLAT per EUR.
Appendix B. Changes in interest rates, GDP and money supply before and during the crisis.
The left vertical axis presents changes in money supply and GDP. Money supply and GDP are indexed to their initial value at the starting point of the data. The right vertical axis presents changes in overnight interest rates. Data cover the period from Q1 1995 to Q3 2009.
Appendix C. Direct and portfolio investments in the economy and abroad.
Data are presented in million USD from Q1 1996 to Q2 2009.

Can policy improve liquidity during a financial crisis?
Appendix D. Exports, imports, current account and capital account.
Data are presented in million USD from Q1 1994 to Q2 2009.

Estonia

Latvia

Lithuania

Denmark

Finland

Sweden
Appendix E. Asset and liability structure of depository financial institutions in Denmark, Finland and Sweden.

The left pane presents the asset structure in the following order: claims on other sectors, claims on central government, claims on nonresidents. The right pane presents the liability structure in the following order: shares and other equity, other shares excl. from broad money, liabilities to central government, liabilities to nonresidents, M2 deposits, M1 deposits.
Appendix F. Asset and liability structure of depository financial institutions in Estonia, Latvia and Lithuania.

The left pane presents the asset structure in the following order: claims on other sectors, claims on central government, claims on nonresidents. The right pane presents the liability structure in the following order: shares and other equity, other shares excl. from broad money, liabilities to central government, liabilities to nonresidents, M2 deposits, M1 deposits.

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LATCOIN: determining medium to long-run tendencies of economic growth in Latvia in real time

Konstantīns Beņkovskis¹,²

Abstract

This paper presents a method of estimating the current state of Latvia’s economy. The evaluation object is medium to long-run growth of real GDP, but not actual GDP itself, which helps to filter out various one-off effects and focus on medium and long-run tendencies. Our indicator, called LATCOIN (Latvia’s Business Cycle Coincidence Indicator), could be viewed as a simple adaptation of new EUROCOIN for Latvia with some changes in methodology. LATCOIN is a monthly estimate of the medium to long-run growth of Latvia’s real GDP, which is produced on the 9th working day of the next month. Using a large panel of macroeconomic variables, a few smooth unobservable factors describing the economy are constructed. Further, these factors are used for the estimation of LATCOIN.

Keywords: Latvia’s real GDP, band-pass filter, coincidence indicator, generalised principal components, real-time performance

JEL classification: C22, C50, E32

Introduction

The most complete and popular indicator of economic activity is real GDP growth. However, two main drawbacks are usually associated with this variable. First, information on domestic activity comes only on a quarterly basis and with a significant delay. The second drawback is related to short-run fluctuations of real GDP, which creates a significant problem for analysing, forecasting, and decision making in real time. Monetary policy makers are usually not interested in such fluctuations and are more concerned about medium-term and fundamental tendencies in the economy.

The first problem has already been addressed for the case of Latvia in several researches, which analysed short-term forecasting possibilities of Latvia’s real GDP. Meļihovs and Rusakova (2005) checked the forecasting ability of business and consumer survey data, Ajevskis and Dāvidsons (2008) showed that dynamic factor models provide good forecasting performance in the short run, and Beņkovskis (2008) used bridge equations with various conjunctural indicators to forecast real GDP. All these papers, however, do not address the second problem of short-term fluctuations in real GDP.

¹ Monetary Policy Department, Bank of Latvia, Email: Konstantins.Benkovskis@bank.lv
² The views expressed in this publication are those of the author, an employee of the Bank of Latvia Monetary Policy Department. The author assumes responsibility for any errors or omissions.
This paper presents an alternative method of estimating the current state of Latvia’s economy. The main difference vis-à-vis previous research papers is that the evaluation object is medium to long-run growth of real GDP, but not actual GDP itself. This helps to filter out various one-off effects and focus on medium and long-run tendencies.

In creating such a method, the author closely follows the new EUROCOIN (Euro Area Business Cycle Coincidence Indicator), which was developed by Altissimo et al. (2006) and is actively used by Banca d’Italia. Our indicator, called LATCOIN (Latvia’s Business Cycle Coincidence Indicator), could be viewed as a simple adaptation of EUROCOIN for Latvia with some changes in methodology. Our main contribution to the literature is the application of estimation methodology to a country that has recently undergone transformation and has a relatively short data history. LATCOIN is a monthly estimate of the medium to long-run growth of Latvia’s real GDP produced on the 9th working day of the next month.

In the theoretical case of infinite data series, evaluation of the medium to long-run component could easily be done by applying the band-pass filter approach. In reality, however, band-pass filtering provides a good approximation in the middle of the sample, while approximations at its ends are very poor. Therefore, band-pass filtering is not an appropriate method for real-time analysis. The idea of the current approach is based on the assumption that various macroeconomic variables capture some information about future GDP dynamics. Using a large panel of macroeconomic variables, a few smooth unobservable factors describing the economy are constructed. Further, these factors, called regressors, are used for estimating LATCOIN.

The paper is structured in the following way. Section 1 gives a definition of the medium to long-run growth of Latvia’s real GDP. Section 2 describes the construction of regressors from a large panel of macroeconomic variables using generalised dynamic factor analysis. Calculations of LATCOIN are given in Section 3, while Section 4 shows the real-time performance of LATCOIN. The final section concludes.

1. Medium to long-run growth of Latvia’s GDP: band-pass filter approach

We would be interested in an indicator of economic activity which inherits the good features of real GDP (e.g. comprehensiveness, inclusion of all sectors of the economy) and at the same time describes only medium and long-run tendencies; moreover, it should be available shortly after the end of the reference period on a monthly basis. The paper will first focus on medium and long-run tendencies of the economy.

Following Altissimo et al. (2006), medium to long-run growth (hereinafter denoted by MLRG) of economic activity is obtained by removing from the quarterly growth of real GDP any fluctuations of a period shorter than or equal to one year. In other words, MLRG is a “smoothed” version of GDP growth. The choice of the one-year threshold is natural, since we are not interested in seasonality and shorter fluctuations.

3 An example of EUROCOIN use in Banca d’Italia can be found at http://eurocoin.bancaditalia.it/.
MLRG is defined considering the spectral decomposition of $y_t$, quarterly growth of real GDP in Latvia. Assuming stationarity, $y_t$ can be represented as the sum of sine and cosine waves with different weights. Our goal is to exclude short waves with a frequency equal to or higher than $\pi/6$ (corresponding to a period of one year), so that as a result MLRG or $c_t$ is obtained. Using the band-pass filter (see Baxter and King, 1999, and Christiano and Fitzgerald, 2003), the medium to long-run component $c_t$ is the following infinite, symmetric, two-sided linear combination of the GDP growth series:

$$c_t = \beta(L)y_t = \sum_{k=-\infty}^{\infty} \beta_k y_{t-k}, \quad \beta_k = \begin{cases} \sin(k\pi/6) / (k\pi) & \text{for } k \neq 0 \\ 1/6 & \text{for } k = 0 \end{cases}$$

(1)

Filter $\beta(L)$ is a low-pass filter which excludes waves of frequency equal to or higher than $\pi/6$. Since $\beta(1)=1$, the mean of $y_t$ (denoted by $\mu$), is retained in $c_t$ while the mean of the excluded part of GDP growth is equal to zero.

Equation (1) cannot be applied in practice as the data on GDP are finite. So, within a finite sample it is possible to get only approximations of $c_t$. According to Altissimo et al. (2006), this is done by augmenting $y_t$ with its sample mean $\hat{\mu}$ in both infinite directions:

$$c^*_t = \beta(L)y^*_t, \quad \text{where} \quad y^*_t = \begin{cases} y_t & \text{if } 1 \leq t \leq T \\ \hat{\mu} & \text{if } t < 1 \text{ or } t > T \end{cases}$$

(2)

This means a $t$-dependent asymmetric truncation of $\beta(L)$ applied to $y_t-\hat{\mu}$, and due to this asymmetry the approximation provided by $c^*_t$ is very poor at the beginning and end of the sample. Another problem arises due to the fact that $y_t$ is observed only quarterly, while we are interested in a more frequent indicator of economic activity, so that interpolation is needed. Several interpolation options are possible. However, as argued by Altissimo et al. (2006), “.. we should keep in mind that the variable we are interested in is $c_t$ but not $y_t$. It turns out that for this purpose the particular interpolation of the missing values in $y_t$ makes no significant difference. Sensible interpolations of the two data points that are missing for each quarter only have effects on the short-run behaviour of the series. Since the short waves are filtered out by $\beta(L)$, the interpolation technique chosen has a negligible effect”. Taking this into account we use the simplest possible interpolation technique, assuming that $y_t$ is not changing within a quarter.

---

4 $y_t = \ln(Y_t) - \ln(Y_{3Q1996})$, where $Y_t$ is the seasonally adjusted real GDP for the period from the first quarter of 1996 to the third quarter of 2009. Data are provided by the Central Statistical Bureau of Latvia (CSB). Of course, it is possible to use non-adjusted GDP data and filter out seasonality using the band-pass filter approach. However, the choice between adjusted and non-adjusted data does not significantly affect the final results.

5 There are filtering techniques which are free of the end-point problem, e.g. the Kalman filter (see Stock and Watson, 1988). However, use of the Kalman filter is limited in short samples. Moreover, some a priori judgements should be made about the data generating process.
Figure 1 shows approximate MLRG, calculated using equation (2) and the quarterly growth of real GDP in Latvia. MLRG is smoother and captures only medium and long-run tendencies in real GDP. As mentioned before, this is only an approximation of MLRG, which performs badly at the beginning and end of the sample while being reasonable in the middle of the sample. Of course, there is no clear threshold where a poor approximation changes into a good one; nevertheless, the first and the last 12 months are marked by a dashed line on the chart, indicating problems with these estimations.

**Figure 1.** Approximate MLRG and quarterly (logarithmic) growth of seasonally adjusted real GDP in Latvia (June 1996–September 2009)

Source: CSB and author’s calculations.

Approximate MLRG fulfils the criteria about the focus on medium and long-run tendencies of economic activity. However, it does not fulfil the timing criterion. Estimations of approximate MLRG are available only together with the data on actual real GDP (at least with a 40-day delay). Moreover, approximation of the last data point is very poor and will improve only gradually as more and more data on the next quarters appear. We need another indicator by which to determine MLRG not only for the past but also in real time.

### 2. Improving estimates of medium to long-run growth using macroeconomic indicators

Real GDP is not the only source of information on economic activity. Statistical offices and other organisations provide data on industrial production, retail sales, international trade in goods, business and consumer confidence, money aggregates, etc. Although these indicators capture only partial information on domestic activity, they have a significant advantage over GDP statistics in terms of availability. These data are released much faster than GDP figures; moreover, they are available at a monthly frequency. A large dataset of macroeconomic indicators could contain variables leading to current real GDP. Altissimo et al. (2006) argue
that “.. the information contained in the future GDP can be partially recovered by projecting approximate MLRG onto a suitable set of linear combinations of current values of these variables”.

One possibility is to choose several macroeconomic variables which would hopefully capture some information about future GDP dynamics. Although this approach is simpler, it omits large amounts of information, as many different macroeconomic indicators are available for use. Dynamic factor analysis could be another option. The idea underpinning this is based on the assumption that the dynamics of macroeconomic variables is determined by a few unobservable factors that can be estimated using broad panel data. These unobservable factors could then be used as regressors for the MLRG variable.

### 2.1 Generalised dynamic factor analysis

Each series in the dataset of macroeconomic indicators ($x_{it}$) is assumed to be the sum of two stationary, mutually orthogonal at all leads and lags, unobservable components – the common component ($\chi_{it}$) and the idiosyncratic component ($\xi_{it}$):

$$x_{it} = \chi_{it} + \xi_{it}$$  \hspace{2cm} (3)

The common component is driven by a small number ($q$) of common shocks $u_{ht}$, $h = 1,...,q$:

$$\chi_{it} = b_{11} (t) u_{1t} + b_{12} (t) u_{2t} + ... + b_{1q} (t) u_{qt}$$  \hspace{2cm} (4)

For simplicity, the model is restricted by assuming that different idiosyncratic components are mutually orthogonal at all leads and lags.

Models (3) and (4) may be further specified by assuming that the common component can be described in terms of a still small number of static factors $F_{kt}$, $k = 1,...,r$, by using static representation:

$$\chi_{it} = a_{i1} F_{1t} + a_{i2} F_{2t} + ... + a_{ir} F_{rt}$$  \hspace{2cm} (5)

Static factors can be found by the approach of Stock and Watson (2002) using the first $r$ principal components of variables $x_{it}$. The drawback of this approach consists in the fact that estimated static factors contain both medium to long-run and short-run components. As a result, MLRG (containing just medium and long-run waves) will be projected on variables which contain short-run fluctuations.

The innovation of the approach by Altissimo et al. (2006) is that they remove both idiosyncratic and short-run components, so that the resulting factors are both common and smooth. Following Forni et al. (2000) and Forni et al. (2005), they use a two-step method, producing an estimate of the spectral density matrix of unobserved components and then use this estimate to obtain the factors by means of generalised principal components.

According to equation (3), the spectral density matrix of $x_{it}$ ($S_{x}(0)$) can be decomposed into the common and idiosyncratic component:
Moreover, as we are not interested in the short-term part of the common component, matrix $S_{z}(\theta)$ can be further decomposed into the medium to long-run and short-run component:

$$S_{z}(\theta) = S_{q}(\theta) + S_{v}(\theta)$$  \hspace{1cm} (7)

where

$$S_{q}(\theta) = \begin{cases} S_{z}(\theta) & \text{for } |\theta| < \pi/6 \\ 0 & \text{for } |\theta| \geq \pi/6 \end{cases}$$

$$S_{v}(\theta) = S_{z}(\theta) - S_{q}(\theta)$$

The choice of $q$ (the number of common shocks) is made using the criterion proposed by Hallin and Liška (2007), and technical details about the estimation of $\hat{S}_{z}(\theta), \hat{S}_{q}(\theta), \hat{S}_{v}(\theta)$, and can be found in Appendix 1.

Integrating equations (6) and (7) over interval $[-\pi, \pi]$, the following decompositions of variance-covariance matrix of $x_{it}$ ($\Sigma_{x}$) can be obtained:

$$\Sigma_{x} = \Sigma_{z} + \Sigma_{\xi} = \Sigma_{q} + \Sigma_{v} + \Sigma_{\xi}$$  \hspace{1cm} (8)

The number of static factors $r$ is determined by the criterion of Bai and Ng (2002). Then, using the estimates of variance-covariance matrices $\hat{\Sigma}_{w}, \hat{\Sigma}_{b}, \hat{\Sigma}_{v}$, we can construct $r$ smooth regressors by solving the generalised eigenvalue problem (see Appendix 1 for technical details).

As a result, we will obtain smooth regressors (denoted as $w_{it}^{m}, k = 1, \ldots, r$, with the superscript $m$ indicating that regressors are expressed as month-on-month changes) extracted from a large panel of macroeconomic variables $x_{it}$. It is assumed that these regressors contain information about future GDP.

### 2.2 Constructing regressors using a large sample of Latvia’s macroeconomic indicators

We use a dataset consisting of 153 monthly macroeconomic variables during the period between January 1996 and December 2009. The choice of variables is based on two criteria: theoretical relevance for economic activity in Latvia and time of release. Most of the variables describe Latvian economic activity (industrial production, retail trade, confidence indicators), while we also take into account the importance of the international environment and include some indicators of the Estonian, Lithuanian, and euro area economy. Several variables which are important indicators of economic activity were not included in the database due to the late time of release or absence of monthly data (e.g. wage and employment statistics, construction indices). The main blocks of macroeconomic indicators are as follows (see detailed description in Appendix 2):
• Business and consumer confidence indicators (63 variables) – the largest block containing variables on Latvia, with the remaining variables on Estonia, Lithuania, and the euro area.

• Industrial production indices (32 variables). Detailed 2 digit NACE categories for Latvia and broad categories for Estonia, Lithuania, and the euro area.

• Retail trade turnover at constant prices in Latvia for different categories of goods (30 variables).

• Variables describing external transactions: exports and imports of goods, services, balance of payments monthly data on the financial account (12 variables).

• Financial data: monetary variables, interest rates, effective exchange rates (12 variables).

• Other variables containing budget indicators, registered unemployment and turnover at ports.

All 153 series were transformed to remove seasonal factors and non-stationarity. Seasonal adjustment was conducted by regressing variables on a set of seasonal dummies, while non-stationarity was removed by first differencing or first log-differencing. Finally, the series were normalised. Panel data \( x_{it} \) are far from being balanced: some indicators are missing data at the end of the sample (e.g. exports and imports of goods), many variables start later than 1996, while other variables are missing observations in the middle (e.g. consumer surveys). Altissimo et al. (2006) solve the problem of end-of-sample imbalance by shifting the time series with missing observations forward. This approach does not work for Latvia, however, as many variables are subject to the beginning-of-sample problem.

**Figure 2.** Common factor calculated by generalised dynamic factor analysis (February 1996–December 2009) and quarterly (logarithmic) growth of seasonally adjusted real GDP in Latvia.
To solve the problem of imbalanced panel, the expectations-maximisation (EM) iterative algorithm introduced by Stock and Watson (2002) is used. As the first step, the missing values are simply set equal to the unconditional mean of the series, and the initial estimation of factors and loadings is made by the principal components. At the \( j \)th step, this reduces to the usual principal component eigenvalue calculation where the missing data are replaced by their expectation conditional on observed data and loadings from the previous iteration are used. The process is terminated when changes in missing observations become negligible.

As already stated, the choice of \( q \) and \( r \) was made according to Hallin and Liška (2007), and Bai and Ng (2002) respectively. Results of information criteria for different \( q \) and \( r \) are reported in Appendix 3. According to the author’s calculations, the proper choice is \( q = 1 \) and \( r = 1 \), suggesting that a set of macroeconomic variables should be described by one stochastic shock and one static factor. This factor explains 8.3% of variety in the dataset variables. Low share of explained variety is implied by the fact that the factor refers only to the medium and long-run component of the data. The increase of \( q \) to 2 does not increase the share of explained variety significantly – it goes up only to 10.3%. Such a result when information criteria indicate the smallest possible number of lags or factors is very typical for Latvia and could be explained by the short length of time series.\(^6\) The same value of \( r \) was also used in the EM algorithm.

Figure 2 reports the result of generalised dynamic factor analysis of the panel consisting of 153 macroeconomic variables. This factor describes monthly changes in the medium to long-run component of Latvia’s economic activity. The factor clearly indicates two periods of crises: the Russian financial crisis in 1998 and the financial crisis in 2008–2009.

It appears that confidence indicators, unemployment, money aggregates and retail trade variables are the most correlated with our estimate of the economic cycle, while variables from external transactions, budget, exchange rate and the manufacturing block are least correlated. This could be explained by the fact that Latvia’s economic growth was largely driven by domestic factors during the boom years. Although the exclusion of less correlated variables from the database did not change the results significantly\(^7\), we did not decrease the dimensions of the database, as the role of external, manufacturing and budget variables could increase in forthcoming years.

### 3. Estimating LATCOIN

When a small number of smooth regressors are constructed, they can be used to estimate MLRG or \( c_t \). Before doing so, the last transformation of regressors is needed, as \( w^m_t \) is expressed as month-on-month changes, while \( c_t \) is expressed as quarter-on-quarter changes (changes over the preceding three-month period). To transform the regressors into quarter-on-quarter change, the following transformation is used:

\(^6\) The increase in the number of factors did not improve the final results. On the contrary, a higher number of factors led to poor performance of the indicator in real time as high historical revisions were observed at the end of the sample.

\(^7\) Results are available upon request.
where $w_{kt}$ is a regressor expressed as quarter-on-quarter change and $L$ is lag operator.

LATCOIN is obtained by projecting $c_t$ on regressors $w_t = \left( w_{kt}, ..., w_{kt} \right)'$ and the constant:

$$
\hat{c}_t = \mu + \hat{\Sigma}_{cw} \hat{\Sigma}_w^{-1} w_t
$$

where $\hat{\Sigma}_{cw}$ is the estimated row vector of covariance between $c_t$ and $w_t$, and $\hat{\Sigma}_w$ is the estimated covariance matrix of $w_t$. While $\hat{\Sigma}_w$ the estimation of $\Sigma$ is a standard one, the estimation of $\hat{\Sigma}_{cw}$ is not so straightforward. One possibility is to calculate covariance between $c_t^*$ (approximate MLRG) and $w_t$. As $c_t^*$ is not an accurate approximation of $c_t$ at the beginning and end of the sample, the end-of sample and beginning-of-sample data should be left aside. As already stated above, there is no clear threshold to classify an approximation as good or poor, so that the question of how many observations should be excluded is open.

Altissimo et al. (2006) propose another approach to estimate $\hat{\Sigma}_{cw}$ directly from cross-covariance between $y_t$ and $w_t$ using cross-spectrum $\hat{S}_{xy}(\theta)$ and integrating it over the interval $[-\pi/6, \pi/6]$ (see Appendix 4 for technical details). Although the results obtained by these two methods are similar, the second approach does not require subjective decisions about data exclusion and therefore is used in the paper.

Using the smooth common factor obtained in the previous part and equations (9) and (10), it is now possible to estimate LATCOIN – the indicator of medium to long-run growth of real GDP in Latvia. LATCOIN (based on information available in January 2010) is reported in Figure 3. An advantage of LATCOIN over approximate MLRG obtained by band-pass filter-

**Figure 3.** LATCOIN, approximate MLRG and quarterly (logarithmic) growth of seasonally adjusted real GDP in Latvia (June 1996–December 2009)
ing is clearly obvious. Unlike approximate MLRG, estimates of LATCOIN are available until December 2009. Therefore, LATCOIN is able to give information about MLRG of real GDP almost in real time, i.e. just a few days after the end of the reference month.

LATCOIN is quite smooth (it refers to the medium and long-run component of GDP growth) and is very similar to the approximation of MLRG in the middle of the sample (2001–2004). The smoothness and fit could also be described formally, using the number of turning points in LATCOIN and $R^2$ of regression of $c_t^*$ over the period $[13, T-12]$ (without the first and the last 12 months of approximate MLRG). The number of turning points of LATCOIN in the sample period is 34, i.e. significantly higher than the number of turning points in approximate MLRG (21). However, a large part of these turning points refer to a relatively short period (2002–2004). The determination coefficient is 0.454 or at a rather low level (especially compared with the one in research by Altissimo et al., 2006), which can be explained by the lack of pronounced cycles in Latvia’s economy during the sample period. LATCOIN clearly indicates two periods when the MLRG of Latvia’s real GDP was negative: the first at the end of 1998 and beginning of 1999 associated with the Russian financial crisis, and the second, more pronounced and prolonged from mid-2008 to end-2009. LATCOIN also captures the period of boom in Latvia’s economy (2002–2007) when average quarterly growth of the medium to long-run component of real GDP was close to 2% (8% in annual terms).

4. Use of LATCOIN in real time

4.1 Real-time performance

To analyse the real-time performance of LATCOIN, a real-time database containing GDP series with different vintages was created. Using this database, one can discover historical GDP figures available for analysis at any particular period. In addition, the real-time database allows identification of what and when GDP data revisions were made. Regrettably, due to lack of information it was not possible to create a real-time database for macroeconomic indicators.

The real-time database contains 61 monthly vintages of quarterly seasonally adjusted real GDP, starting with data available in January 2005 (1996 Q1–2004 Q3) and finishing with data available in January 2010 (1996 Q1–2009 Q3). Appendix 5 compares some vintages of real GDP: the first available in the database (January 2005), the last available (January 2010), and one in the middle (July 2007). It can be noted that in several quarters the revisions are quite remarkable. These changes traditionally come from two sources: revisions in non-adjusted real GDP numbers, and changes due to the seasonal adjustment procedure. The other important source of GDP figures is one-off changes in methodology, as starting from December 2008 the CSB switched to chain-linked real GDP estimation, so that GDP data vintages before and after 2009 are not fully comparable.

Figure 4 reports a pseudo real time evaluation of LATCOIN (“pseudo” refers to the absence of real-time data on macroeconomic indicators). The exercise imitates the estimates of LATCOIN.
COIN on a monthly basis starting from January 2005 until January 2010. The estimations are made on the 9th working day of the next month, and LATCOIN values for 6 previous months are reported.

**Figure 4.** Real time performance of LATCOIN from January 2005 until January 2010 (June 2004–December 2009)

The exercise shows that historical revisions of LATCOIN are small, with a single exception of the end of 2008 and the beginning of 2009. However, even these revisions could be regarded as small compared with the magnitude of contraction in activity during the period. Therefore, it can be concluded that LATCOIN provides a stable evaluation of MLRG in real time.

### 4.2 Behaviour around turning points

Another important characteristic of LATCOIN is the ability to give a correct signal of MLRG turning points in real time. Let \( \hat{c}_t(\tau) \) be the LATCOIN value at time \( t \), estimated at time point \( \pi \) (it should be noted that the latest available value of the indicator at time \( t \) is always \( \hat{c}_{t-1}(t) \)). Following the approach of Altissimo et al. (2006), LATCOIN is considered to signal the slope sign change of MLRG in the previous month if:

- A sign change occurs between \( \Delta \hat{c}_{t-1}(t) \) and \( \Delta \hat{c}_{t-2}(t) \): obviously, if the sign changes from negative to positive, the signal is positive.
- The signs of \( \Delta \hat{c}_{t-2}(t) \) and \( \Delta \hat{c}_{t-2}(t-1) \) coincide indicating that the signal is consistent.
- The signs of \( \Delta \hat{c}_{t-3}(t-1) \) and \( \Delta \hat{c}_{t-3}(t-1) \) coincide ruling out two consecutive opposite signals.

The short period of the real-time exercise does not allow us to conduct a formal test on the performance of LATCOIN around the turning points of MLRG. Moreover, evaluation of
LATCOIN turning point signals (see Figure 5) is made even more difficult by changes in the methodology by the CSB. As mentioned in the previous subsection, starting from December 2008 the CSB switched to chain-linked real GDP estimation. Unlike many other data revisions without any significant effect on approximate MLRG, the switch to chain-linked data had a major impact on approximate MLRG and consequently on LATCOIN calculations.

Figure 5. Signals of MLRG turning points from LATCOIN (May 2004–December 2009)

The next factor, last but not least, that makes formal evaluation of LATCOIN performance more complicated is the absence of pronounced business cycles in Latvian data until recent times. A real-time exercise shows that LATCOIN gave several turning point signals in 2005–2006, yet MLRG had only minor fluctuations around the average level (with reference to approximate MLRG calculated before December 2008).

The first pronounced change in the medium to long-run tendency occurred in May–June of 2007 while LATCOIN gave a negative signal as early as December 2006 (the negative slope of LATCOIN in early 2007 is also clearly seen in Figure 4). It is difficult to judge whether this signal by LATCOIN should be treated as right or wrong, yet it is more likely that macroeconomic variables were pointing in advance to a medium to long-run slowdown in Latvia’s economy. Also, the positive signal in August 2007 came prior to a short-lived increase in approximate MLRG. The next signal came in May 2008 giving a very timely indication of a pending negative turning point. It is too early to evaluate the preciseness of the next two signals, although the information available so far shows that the first signal was wrong (or probably indicated a future turning point in advance), while the second was almost in time.
5. Conclusions

LATCOIN is a monthly estimate of the medium to long-run growth of Latvia’s real GDP produced on the 9th working day of the next month. Our indicator could be viewed as a simple adaptation of new EUROCOIN for Latvia with some changes in methodology. The main contribution to the literature is the implementation of methodology to a country, which has recently undergone a process of transformation and has a relatively short data history.

The target, MLRG, has been defined as quarterly GDP growth filtered out from all fluctuations of a period shorter than one year. To avoid a potentially large end-of-sample bias, the target was projected on smooth regressors describing the main medium to long-run tendencies of the economy. The regressors, in turn, were obtained using a large panel of macroeconomic variables.

LATCOIN can give information about the MLRG of Latvia’s real GDP almost in real time, i.e. a few days after the end of the reference period. The indicator is smooth and is very similar to the approximation of MLRG in the middle of the sample. Although the determination coefficient is low, this could be explained by the lack of pronounced cycles in Latvia’s economy during the sample period. Moreover, the performance of LATCOIN as a real time estimator has been analysed. It could be concluded that LATCOIN has good potential and could be used for estimating the current state of Latvia’s economy, although some additional formal test should be conducted when more information becomes available.

References


Appendix 1. Generalised dynamic factor analysis

First, covariance matrices of $x_t$ at lags $k = -M, ..., M$ are estimated:

$$\hat{\Sigma}_x(k) = \frac{1}{(T-k)} \sum_t x_t x_{t-k}^\prime$$  (A1.1)

where $t$ varies from $\max[1, \ 1+k]$ to $\min[T, \ T+k]$. The spectrum of $x_t$ at $2J+1$ equally spaced points $\theta_j$ is estimated using the Bartlett lag-window estimator:

$$\hat{S}_x(\theta) = \frac{1}{2\pi} \sum_{k=-M}^{M} W_k \hat{\Sigma}_x(k) e^{i\theta k}$$  (A1.2)

where

$$W_k = 1 - \frac{|k|}{M+1}$$

$$\theta_j = \frac{2\pi j}{2J+1}, \quad j = -J, ..., J.$$

Following Altissimo et al. (2006), $J=60$ and $M=24$.

Second, the eigenvalues and eigenvectors of $\hat{S}_x(\theta)$ at each frequency are computed. Let $\Lambda(\theta)$ be the $q \times q$ diagonal matrix having on the diagonal the first $q$ eigenvalues in descending order, and let $U(\theta)$ be the matrix having on the columns the first $q$ eigenvectors. The estimate of for every $\theta$ is

$$\hat{S}_x(\theta) = U(\theta) \Lambda(\theta) U'(\theta)$$  (A1.3)

Third, $\hat{S}_x(\theta)$ is integrated over all points $\theta_j$ to get the estimate of $\Sigma_x$, and $\hat{S}_x(\theta)$ is integrated over frequency interval $[-\pi/6, \ \pi/6]$ to get the estimate of $\Sigma_\phi$:

$$\hat{S}_x = \frac{2\pi}{2J+1} \sum_{j=-J}^{J} \hat{S}_x(\theta)$$  (A1.4)

$$\hat{S}_\phi = \frac{2\pi}{2J+1} \sum_{j=-0}^{J} \hat{S}_x(\theta)$$  (A1.5)

The estimate of idiosyncratic variance-covariance matrix $\Sigma_\xi$ is obtained as

$$\hat{\Sigma}_\xi = diag(\hat{\Sigma}_x - \hat{\Sigma}_\phi)$$  (A1.6)

where all off-diagonal elements of $\Sigma_\xi$ are set to zero. This is consistent with the assumption of mutual orthogonality of idiosyncratic components.

Finally, after matrices $\hat{\Sigma}_x$, $\hat{\Sigma}_\phi$ and $\hat{\Sigma}_\xi$ are estimated, we determine the linear combination of variables in the panel that maximises variance of the common component in the low-frequency band. Then we determine another linear combination with the same property under the constraint of orthogonality to the first, and so on.

According to Altissimo et al. (2006), we look for vectors $v_k$, $k = 1, ..., n$, and the corresponding linear combinations $w_k^m = w_k' x_t$, solving the sequence of maximisation problems:
\[
\max_{v \in \mathbb{R}^N} \langle \hat{\Sigma}_y v, \hat{\Sigma}_h v \rangle, \quad \text{s.t.} \quad \langle \hat{\Sigma}_x (\hat{\Sigma}_y + \hat{\Sigma}_h) v \rangle = 1, \quad \langle \hat{\Sigma}_x (\hat{\Sigma}_y + \hat{\Sigma}_h) v_h \rangle = 0, \quad \text{for } h < k,
\]

where \( v_0 = 0 \), and \( v_h \) solves problem \( h \).

The solution of this sequence of problems is given by generalised eigenvectors \( v_1, \ldots, v_n \) associated with generalised eigenvalues \( \lambda_1, \ldots, \lambda_n \), ordered from biggest to smallest, of the pair of matrices \( (\hat{\Sigma}_x, \hat{\Sigma}_y + \hat{\Sigma}_h) \), i.e. the vectors satisfying:

\[
\hat{\Sigma}_y v_k = \lambda_k (\hat{\Sigma}_x + \hat{\Sigma}_h) v_k \tag{A1.7}
\]

with normalisation constraints \( \langle \hat{\Sigma}_x (\hat{\Sigma}_y + \hat{\Sigma}_h) v_k \rangle = 1 \) and \( \langle \hat{\Sigma}_x (\hat{\Sigma}_y + \hat{\Sigma}_h) v_h \rangle = 0 \) for \( k \neq h \).
## Appendix 2. List of monthly macroeconomic indicators

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<td>- Retail Trade Survey – Business activity expectations over the next 3 months</td>
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<tr>
<td>- Retail Trade Survey – Employment expectations over the next 3 months</td>
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<tr>
<td>- Construction Survey – Confidence Indicator</td>
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<tr>
<td>- Construction Survey – Building activity development over the past 3 months</td>
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<tr>
<td>- Construction Survey – Main factors currently limiting your building activity – Balance</td>
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<tr>
<td>- Construction Survey – Main factors currently limiting your building activity – None</td>
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<tr>
<td>- Construction Survey – Main factors currently limiting your building activity – Insufficient demand</td>
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<tr>
<td>- Construction Survey – Main factors currently limiting your building activity – Weather conditions</td>
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<tr>
<td>- Construction Survey – Main factors currently limiting your building activity – Shortage of labour force</td>
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<tr>
<td>- Construction Survey – Main factors currently limiting your building activity – Shortage of material and/or equipment</td>
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<tr>
<td>- Construction Survey – Evolution of your current overall order books</td>
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<td>- Construction Survey – Employment expectations over the next 3 months</td>
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<tr>
<td>- Construction Survey – Prices expectations over the next 3 months</td>
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<tr>
<td><strong>Euro Area:</strong></td>
<td></td>
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<tr>
<td>- Total Economic Sentiment Indicator (ESI)</td>
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<tr>
<td>- Industry Survey – Confidence Indicator</td>
<td></td>
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<tr>
<td>- Services Survey – Confidence Indicator</td>
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<td>- Consumer Survey – Confidence Indicator</td>
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<tr>
<td>- Retail Trade Survey – Confidence Indicator</td>
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<tr>
<td>- Construction Survey – Confidence Indicator</td>
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<tr>
<td>Estonia:</td>
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<td>-----------------------------</td>
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<tr>
<td>− Total Economic Sentiment Indicator (ESI)</td>
<td></td>
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<tr>
<td>− Industry Survey – Confidence Indicator</td>
<td></td>
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<tr>
<td>− Services Survey – Confidence Indicator</td>
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<tr>
<td>− Consumer Survey – Confidence Indicator</td>
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<tr>
<td>− Retail Trade Survey – Confidence Indicator</td>
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<td>− Construction Survey – Confidence Indicator</td>
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<thead>
<tr>
<th>Lithuania:</th>
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<tbody>
<tr>
<td>− Total Economic Sentiment Indicator (ESI)</td>
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<tr>
<td>− Industry Survey – Confidence Indicator</td>
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<tr>
<td>− Services Survey – Confidence Indicator</td>
</tr>
<tr>
<td>− Consumer Survey – Confidence Indicator</td>
</tr>
<tr>
<td>− Retail Trade Survey – Confidence Indicator</td>
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<tr>
<td>− Construction Survey – Confidence Indicator</td>
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</tbody>
</table>

### Industrial production indices (working day adjusted)

**Latvia:**
- Mining and quarrying
- Manufacture of food products
- Manufacture of beverages
- Manufacture of textiles
- Manufacture of wearing apparel
- Manufacture of wood and of products of wood and cork, except furniture
- Manufacture of paper and paper products
- Printing and reproduction of recorded media
- Manufacture of chemicals and chemical products
- Manufacture of basic pharmaceutical products and pharmaceutical preparations
- Manufacture of rubber and plastic products
- Manufacture of other non-metallic mineral products
- Manufacture of basic metals
- Manufacture of fabricated metal products, except machinery and equipment
- Manufacture of computer, electronic and optical products
- Manufacture of electrical equipment
- Manufacture of machinery and equipment n.e.c.
- Manufacture of motor vehicles, trailers and semi-trailers
- Manufacture of other transport equipment
- Manufacture of furniture
- Other manufacturing
- Repair and installation of machinery and equipment
- Electricity, gas, steam and air conditioning supply

**Euro Area:**
- Mining and quarrying
- Manufacturing
- Electricity, gas, steam and air conditioning supply

**Estonia:**
- Mining and quarrying
- Manufacturing
- Electricity, gas, steam and air conditioning supply

**Lithuania:**
- Mining and quarrying
- Manufacturing
- Electricity, gas, steam and air conditioning supply
Retail trade turnover at constant prices (seasonally adjusted)

Latvia:
- Retail trade, total, including automotive fuel
- Retail trade, total, except of automotive fuel
- Retail sale of automotive fuel in specialised stores
- Retail sale of food, beverages or tobacco, total
- ...retail sale in non-specialised stores with food, beverages or tobacco predominating
- ...retail sale of food, beverages and tobacco in specialised stores
- Retail trade of non-food products, including automotive fuel
- Retail trade of non-food products, except automotive fuel
- Other retail sale in non-specialised stores
- Retail sale of computers, peripheral units, software telecommunications equipment in specialised stores
- Retail sale of textiles, clothing, footwear and leather goods in specialised stores
- ...retail sale of textiles in specialised stores
- ...retail sale of clothing, footwear and leather goods in specialised stores
- Retail sale of audio and video equipment in specialised stores
- Retail sale of hardware, paints and glass in specialised stores
- Retail sale of carpets, rugs, wall and floor coverings in specialised stores
- Retail sale of electrical household appliances in specialised stores
- Retail sale of furniture, lighting equipment and other household articles in specialised stores
- Retail sale of music and video recordings in specialised stores
- Retail sale of books, newspapers and stationery in specialised stores
- Retail sale of sporting equipment, games and toys in specialised stores
- Dispensing chemist in specialised stores, retail sale of medical, orthopaedic goods, cosmetic articles in specialised stores
- ...dispensing chemist in specialised stores and retail sale of medical and orthopaedic goods in specialised store
- ...retail sale of cosmetic and toilet articles in specialised stores
- Retail sale of flowers, plants, seeds, fertilisers, pet animals and pet food in specialised stores
- Retail sale of watches and jewellery and other retail sale of new goods in specialised stores
- Retail sale of second-hand goods in stores
- Retail sale via stalls and markets
- Retail sale via mail order houses or via Internet
- Other retail sale not in stores, stalls or markets

External transactions:

Latvia:
- Merchandise exports (f.o.b.)
- Merchandise imports (c.i.f.)
- Balance of Payments – Services credit
- Balance of Payments – Services debit
- Balance of Payments – Income balance
- Balance of Payments – Current transfers
- Balance of Payments – Capital account
- Balance of Payments – Foreign direct investments
- Balance of Payments – Portfolio investments
- Balance of Payments – Other investments
- Balance of Payments – Reserves
- Balance of Payments – Errors and omissions
<table>
<thead>
<tr>
<th>Financial variables:</th>
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<tbody>
<tr>
<td>Latvia:</td>
</tr>
<tr>
<td>– Broad money M3</td>
</tr>
<tr>
<td>– Currency in circulation (average)</td>
</tr>
<tr>
<td>– 3 months RIGIBOR</td>
</tr>
<tr>
<td>– Long term deposit interest rates in lats</td>
</tr>
<tr>
<td>– Short term deposit interest rates in lats</td>
</tr>
<tr>
<td>– Long term credit interest rates in lats</td>
</tr>
<tr>
<td>– Short term credit interest rates in lats</td>
</tr>
<tr>
<td>– Nominal Effective Exchange Rate (NEER) of lats – total</td>
</tr>
<tr>
<td>– Nominal Effective Exchange Rate (NEER) of lats – developed countries</td>
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<tr>
<td>– Nominal Effective Exchange Rate (NEER) of lats – developing countries</td>
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<table>
<thead>
<tr>
<th>Euro Area:</th>
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<tbody>
<tr>
<td>– 3 months EURIBOR</td>
</tr>
<tr>
<td>– EUR/USD exchange rate</td>
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<thead>
<tr>
<th>Other variables:</th>
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<tbody>
<tr>
<td>Latvia:</td>
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<tr>
<td>– Registered unemployment rate</td>
</tr>
<tr>
<td>– Total tax revenues</td>
</tr>
<tr>
<td>– Expenditures of basic budget</td>
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<tr>
<td>– Turnover of ports</td>
</tr>
</tbody>
</table>
Appendix 3. Information criteria for different $q$ and $r$

<table>
<thead>
<tr>
<th>$q$</th>
<th>Hallin and Liška (2007) information criteria</th>
<th>$r$</th>
<th>Bai and Ng (2002) information criteria ($q = 1$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1704</td>
<td>1</td>
<td>-0.0427</td>
</tr>
<tr>
<td>2</td>
<td>0.1990</td>
<td>2</td>
<td>-0.0093</td>
</tr>
<tr>
<td>3</td>
<td>0.2334</td>
<td>3</td>
<td>0.0419</td>
</tr>
<tr>
<td>4</td>
<td>0.2725</td>
<td>4</td>
<td>0.0937</td>
</tr>
<tr>
<td>5</td>
<td>0.3149</td>
<td>5</td>
<td>0.1507</td>
</tr>
</tbody>
</table>

Source: author’s calculations.

Appendix 4. Estimation of cross-covariance between $c_t^*$ and $w_t$

First, the covariance between $y_t$ and $w_t$ is estimated at lags $k = -M, ..., M$:

$$
\hat{\Sigma}_{yw}(k) = \frac{1}{[(T-k)/3]-1} \sum_{l} y_{t-l} w_{t-l-k}
$$  \hspace{1cm} (A3.1)

where $l$ varies from $\max[1, 1+[(k+1)/3]]$ to $\min[T/3, (T+k)/3]]$.

Second, cross-spectrum $S_{yw}$ at $2J+1$ equally spaced points $\theta_j$ is estimated using the Bartlett lag-window estimator:

$$
\hat{S}_{yw}(\theta_j) = \frac{1}{2\pi} \sum_{k=-M}^{M} W_k \hat{\Sigma}_{yw}(k)e^{-\theta_j k}
$$  \hspace{1cm} (A3.2)

where

$$
W_k = 1 - \frac{|k|}{M+1}
$$

$$
\theta_j = \frac{2\pi j}{2J+1}, \quad j = -J, ..., J.
$$

As in Appendix 2, $J=60$ and $M=24$.

Finally, $\hat{\Sigma}_{cw}$ is calculated by integrating the cross-spectrum over the relevant frequency interval $[-\pi/6, \pi/6]$:

$$
\hat{\Sigma}_{cw} = \frac{2\pi}{2J+1} \sum_{j=-10}^{10} \hat{S}_{yw}(\theta_j)
$$  \hspace{1cm} (A3.3)
Appendix 5. Different vintages of quarterly growth of Latvia’s seasonally adjusted real GDP (1996 Q2–2009 Q3)

Source: CSB and author’s calculations.