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

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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.

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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.

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1 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.\(^4\) 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:

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

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:

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

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.\(^5\)

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.

\(^4\) \(y_t = \ln(y_t^\ast) - \ln(y_{t-1}^\ast)\), where \(y_t^\ast\) 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 \textit{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)

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 ($\xi_{it}$):

$$X_{it} = \chi_{it} + \xi_{it} \quad (3)$$

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

$$\chi_{it} = b_{i1}(L)u_{i1} + b_{i2}(L)u_{i2} + \ldots + b_{iq}(L)u_{iq} \quad (4)$$

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 $F_{kt}$, $k = 1, \ldots, r$, by using static representation:

$$\chi_{it} = a_{i1}F_{i1} + a_{i2}F_{i2} + \ldots + a_{ir}F_{ir} \quad (5)$$

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 \( S_x(\theta) \) can be further decomposed into the medium to long-run and short-run component:

\[
S_x(\theta) = S_q(\theta) + S_v(\theta)
\]

where

\[
S_q(\theta) = \begin{cases} 
S_z(\theta) & \text{for } |\theta| < \frac{\pi}{6} \\
0 & \text{for } |\theta| \geq \frac{\pi}{6}
\end{cases}
\]

\[
S_v(\theta) = S_x(\theta) - S_q(\theta)
\]

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:

\[
\Sigma_x = \Sigma_z + \Sigma_\zeta = \Sigma_q + \Sigma_v + \Sigma_\zeta
\]

The number of static factors \( r \) is determined by the criterion of Bai and Ng (2002). Then, using the estimates of variance-covariance matrices \( \hat{\Sigma}_w, \hat{\Sigma}_q, \hat{\Sigma}_v \), 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 \( w_{km}^{m} \), \( k = 1, \ldots, r \), 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.

Source: CSB and author’s calculations.
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 significantly7, 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 $c_i$. Before doing so, the last transformation of regressors is needed, as $w_i^m$ is expressed as month-on-month changes, while $c_i$ 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:

\[ w_i^m = \frac{(w_i^m - w_{i-1}^m) \times 12}{3} \]

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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 $w_t = (w_{k1},...,w_{kn})'$ and the constant:

$$\hat{c}_t = \hat{\mu} + \hat{\Sigma}_{cw} \hat{\Sigma}_w^{-1} w_t$$  \hspace{1cm} (10)

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 $\Sigma_w$ 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 $\hat{\Sigma}_{yw}(\theta)$ 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)

Sources: CSB and author’s calculations.
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 LAT-

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$^8$ The turning point is defined as a change in slope of $c_t^*$. 
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 $\tau$ (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 $\Delta \hat{c}_{t-2}(t)$ and $\Delta \hat{c}_{t-3}(t)$: obviously, if the sign changes from negative to positive, the signal is positive.
- The signs of $\Delta \hat{c}_{t-2}(t)$ and $\Delta \hat{c}_{t-3}(t-1)$ coincide indicating that the signal is consistent.
- The signs of $\Delta \hat{c}_{t-3}(t-1)$ and $\Delta \hat{c}_{t-4}(t-1)$ 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 $k = -M, \ldots, M$ are estimated:

$$\hat{\Sigma}_x(k) = \frac{1}{(T-k)} \sum_t x_t x_{t-k}'$$  \hspace{1cm} (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:

$$\hat{\Sigma}_x(\theta) = \frac{1}{2\pi} \sum_{k=-M}^{M} W_k \hat{\Sigma}_x(k) \phi^{\theta,j,k}$$  \hspace{1cm} (A1.2)

where

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

$$\theta_j = \frac{2\pi j}{2J + 1}, \hspace{0.5cm} j = -J, \ldots, J.$$

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

Second, the eigenvalues and eigenvectors of $\hat{\Sigma}_x(\theta)$ 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 $\Sigma$ for every $\theta$ is

$$\hat{\Sigma}_x(\theta) = U(\theta) \Lambda(\theta) U'(\theta)$$  \hspace{1cm} (A1.3)

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

$$\hat{\Sigma}_x = \frac{2\pi}{2J + 1} \sum_{j=-J}^{J} \hat{\Sigma}_x(\theta_j)$$  \hspace{1cm} (A1.4)

$$\hat{\Sigma}_{\phi} = \frac{2\pi}{2J + 1} \sum_{j=-6}^{6} \hat{\Sigma}_x(\theta_j)$$  \hspace{1cm} (A1.5)

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

$$\hat{\Sigma}_\xi = \text{diag} \left( \hat{\Sigma}_x - \hat{\Sigma}_{\phi} \right)$$  \hspace{1cm} (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 $\nu_k$, $k = 1, \ldots, n$, and the corresponding linear combinations $w_{kt} = w_k x_t$, solving the sequence of maximisation problems:
\[
\max_{v \in \mathbb{R}^n} v^T \tilde{\Sigma}_v v, \quad \text{s.t.} \quad v^T (\tilde{\Sigma}_x + \tilde{\Sigma}_e) v = 1, \quad v^T (\tilde{\Sigma}_x + \tilde{\Sigma}_e) v_h = 0, \quad \text{for } h < k,
\]

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 \( (\tilde{\Sigma}_x, \tilde{\Sigma}_x + \tilde{\Sigma}_e) \), i.e. the vectors satisfying:

\[
\tilde{\Sigma}_x v_k = \lambda_k (\tilde{\Sigma}_x + \tilde{\Sigma}_e) v_k \quad \text{(A1.7)}
\]

with normalisation constraints \( v_k^T (\tilde{\Sigma}_x + \tilde{\Sigma}_e) v_k = 1 \) and \( v_k^T (\tilde{\Sigma}_x + \tilde{\Sigma}_e) v_h = 0 \) for \( k \neq h \).
## Appendix 2. List of monthly macroeconomic indicators

<table>
<thead>
<tr>
<th>Indicator Type</th>
<th>Latvia:</th>
<th>Euro Area:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Business and consumer confidence indicators (seasonally adjusted)</strong></td>
<td><strong>Latvia:</strong></td>
<td><strong>Euro Area:</strong></td>
</tr>
</tbody>
</table>
| Total Economic Sentiment Indicator (ESI) | - Industry Survey – Confidence Indicator  
- Industry Survey – Production trend observed in recent months  
- Industry Survey – Assessment of order-book levels  
- Industry Survey – Assessment of export order-book levels  
- Industry Survey – Assessment of stocks of finished products  
- Industry Survey – Production expectations for the months ahead  
- Industry Survey – Selling price expectations for the months ahead  
- Industry Survey – Employment expectations for the months ahead  
- Services Survey – Confidence Indicator  
- Services Survey – Business situation development over the past 3 months  
- Services Survey – Evolution of the demand over the past 3 months  
- Services Survey – Expectation of the demand over the next 3 months  
- Services Survey – Evolution of the employment over the past 3 months  
- Services Survey – Expectations of the employment over the next 3 months  
- Services Survey – Expectations of the prices over the next 3 months  
- Consumer Survey – Confidence Indicator  
- Consumer Survey – Financial situation over last 12 months  
- Consumer Survey – Financial situation over next 12 months  
- Consumer Survey – General economic situation over last 12 months  
- Consumer Survey – General economic situation over next 12 months  
- Consumer Survey – Price trends over last 12 months  
- Consumer Survey – Price trends over next 12 months  
- Consumer Survey – Unemployment expectations over next 12 months  
- Consumer Survey – Major purchases at present  
- Consumer Survey – Major purchases over next 12 months  
- Consumer Survey – Savings at present  
- Consumer Survey – Savings over next 12 months  
- Retail Trade Survey – Confidence Indicator  
- Retail Trade Survey – Business activity (sales) development over the past 3 months  
- Retail Trade Survey – Volume of stock currently hold  
- Retail Trade Survey – Orders expectations over the next 3 months  
- Retail Trade Survey – Business activity expectations over the next 3 months  
- Retail Trade Survey – Employment expectations over the next 3 months  
- Construction Survey – Confidence Indicator  
- Construction Survey – Building activity development over the past 3 months  
- Construction Survey – Main factors currently limiting your building activity – Balance  
- Construction Survey – Main factors currently limiting your building activity – None  
- Construction Survey – Main factors currently limiting your building activity – Insufficient demand  
- Construction Survey – Main factors currently limiting your building activity – Weather conditions  
- Construction Survey – Main factors currently limiting your building activity – Shortage of labour force  
- Construction Survey – Main factors currently limiting your building activity – Shortage of material and/or equipment  
- Construction Survey – Evolution of your current overall order books  
- Construction Survey – Employment expectations over the next 3 months  
- Construction Survey – Prices expectations over the next 3 months  | - Total Economic Sentiment Indicator (ESI)  
- Industry Survey – Confidence Indicator  
- Services Survey – Confidence Indicator  
- Consumer Survey – Confidence Indicator  
- Retail Trade Survey – Confidence Indicator  
- Construction Survey – Confidence Indicator |
**Estonia:**
- Total Economic Sentiment Indicator (ESI)
- Industry Survey – Confidence Indicator
- Services Survey – Confidence Indicator
- Consumer Survey – Confidence Indicator
- Retail Trade Survey – Confidence Indicator
- Construction Survey – Confidence Indicator

**Lithuania:**
- Total Economic Sentiment Indicator (ESI)
- Industry Survey – Confidence Indicator
- Services Survey – Confidence Indicator
- Consumer Survey – Confidence Indicator
- Retail Trade Survey – Confidence Indicator
- Construction Survey – Confidence Indicator

**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
**Financial variables:**

**Latvia:**
- Broad money M3
- Currency in circulation (average)
- 3 months RIGIBOR
- Long term deposit interest rates in lats
- Short term deposit interest rates in lats
- Long term credit interest rates in lats
- Short term credit interest rates in lats
- Nominal Effective Exchange Rate (NEER) of lats – total
- Nominal Effective Exchange Rate (NEER) of lats – developed countries
- Nominal Effective Exchange Rate (NEER) of lats – developing countries

**Euro Area:**
- 3 months EURIBOR
- EUR/USD exchange rate

**Other variables:**

**Latvia:**
- Registered unemployment rate
- Total tax revenues
- Expenditures of basic budget
- Turnover of ports
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 $k = -M, ..., M$:

$$
\hat{\Sigma}_{yw}(k) = \frac{1}{(T-k)/3} \sum_{t} y_{t-i} w_{t-i-k}
$$

where $l$ varies from $\max[0, 1 + \lceil (k+1)/3 \rceil]$ to $\min\left\lfloor T/3 \right\rfloor, \left\lceil (T + k)/3 \right\rceil$.

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

$$
\hat{S}_{yw}(\theta) = \frac{1}{2\pi} \sum_{k=-M}^{M} W_k \hat{S}_{yw}(k) e^{-\theta k}
$$

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 $[-\pi/6, \pi/6]$:

$$
\hat{\Sigma}_{cw} = \frac{2\pi}{2J+1} \sum_{j=-10}^{10} \hat{S}_{yw}(\theta)
$$

Hallin and Liška (2007) information criteria, Bai and Ng (2002) information criteria ($q = 1$)
Appendix 5. Different vintages of quarterly growth of Latvia’s seasonally adjusted real GDP (1996 Q2–2009 Q3)

Source: CSB and author’s calculations.