
Replication, development and evaluation of a GDP indicator for the Swedish business cycle

CAN THE FRAMEWORK OF ECB'S INDICATOR ALI BE USED TO CREATE AN
INDICATOR FOR THE SWEDISH BUSINESS CYCLE?

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Abstract

This study shows that the framework used to construct the successful Euro Area Leading Indicator (ALI), developed by de Bondt and Hahn on behalf of the European Central Bank, can successfully be applied to the Swedish business cycle. The ALI type indicator constructed in this study is a weighted index of nine macroeconomic series and accurately predicts the Swedish business cycle by three months (or longer). A data driven indicator using Principal Component Analysis is constructed for comparison, and leads the Swedish business cycle by seven months. It has zero bias whereas the ALI Sweden indicator slightly underestimates the business cycle, but is slightly more accurate than the data driven indicator. Both indicators are efficient. An out-of-sample real time evaluation confirms the indicators' good performance. A comparison of the series filtered with the HP-filter and the one sided RW-filter shows that the RW-filtered is superior as it filters out the high frequent noise and doesn't introduce spurious cycles. Service Production Index is found to not be a better proxy for the business cycle than Industrial Production Index. This study suggests the use of both indicators: the ALI Sweden indicator for its accurate and transparent forecast and the data driven indicator for its long lead time and zero bias.

Key words: leading indicator, index, Principal Component Analysis, data-driven, turning point, filter, bias, efficiency, accuracy

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1 Introduction

In 1946, the economists Arthur F. Burns and Wesley C. Mitchell wrote the pioneering book *Measuring business cycles* in which they provide for the first time a standard modern systematic definition of a business cycle and how to measure the business cycle using a deviation from trend method. But already in 1930, Burns and Mitchell developed indicators to forecast the business cycle (Burns and Mitchell, 1930). Since Burns and Mitchell's indicator in 1930, a plethora of indicators has emerged. Indicators are variables that can either co-move with the business cycle, lag or lead the business cycle. An example of a lagging indicator is unemployment because it changes as a reaction to the business cycle. The stock market on the other hand, is a leading indicator because it moves ahead of the rest of the economy. It recovers earlier from a trough and declines earlier after a peak. Looking at a leading indicator provides useful information about the near future in the business cycle. Economic indicators are today very popular among industries, governments and organizations as a tool to get a quick overview of the economic conditions. For a firm, a quick indication of the near economic development implies better planning of production, optimal new hiring etc. For a government, an early indication of a coming upturn or downturn in the economic business cycle enables well-balanced policy interventions and budget planning. Therefore, a constant work of developing and examining new and old economic indicators is warranted. This study takes the benchmark in the successful Euro Area leading economic indicator (ALI), developed by the European central bank in 2010, to investigate whether the framework of ALI can be used to develop a successful leading indicator for the Swedish business cycle.

In the foremath of indicators' popularity and before indicators were a natural part in economic forecasting, indicators' validity was debated. Koopmans (1947) claims that the work of Mitchell and Burns is based on empirical observations rather than theoretical underpinning, which they argue "limits the value to economic science and to the maker of policies" (Koopmans, 1947). Since then, a vast literature has emerged which has both improved theoretical underpinning as well as methodology in terms of how to optimally extract the cycle from the trend, choice of reference business cycle and choice of evaluation methods. It's common to distinguish between model-based indicators and non-model indicators. The former is derived in an econometric setting and permits the computation of standard errors around the index. Model-based indicators may allow for feed-back effects or, like in Hamilton's (1989) Markov switching model, allow the growth rate of the variables to vary depending on the status of the business cycle. In a non-model indicator, no such effects exist. The index consists

of a number of series weighted together to one series. If the series lead the business cycle, so will the the index. A non-model based indicator is attractive because of its transparent construction as well as easy interpretation. Marcellino (2006) examined a large group of American indicators and found that non-model indicators often performed empirically better than model-based indicators (Marcellino, 2006).

Today, no public leading indicator exists for the Swedish economy that predicts the full business cycle. Among non-model based indicators, it has been shown that the original ALI indicator for the Euro area, hereafter *ALI orig*, performs very well and accurately detects turning points in the Euro Area business cycle at an early stage (de Bondt and Hahn, 2010). A successful ALI indicator for the Swedish business cycle would provide a new possibility of a transparent, quick and accurate forecasting tool to predict the full economy's near future. Therefore this study will investigate whether a new ALI, using the framework of the *ALI orig* (presented by de Bondt and Hahn), adjusted for the Swedish business cycle, can successfully predict turning points in the Swedish business cycle.

In the construction of ALI Sweden, there are two inherited vulnerabilities in the process. The first one is how the series are selected. The selection process follows a general to specific approach using three criteria to find suitable series to the indicator. The criteria are however not exhaustive and require interpretation and decision making by the constructor. This phase in the construction process opens up for possible bias. Because I rise to the challenge to create an ALI type indicator using these broad criteria, I will also construct a data driven indicator constructed solely by the data itself for comparison. The data driven indicator is derived from a pool of data from which a common component is extracted, using the the so called Principal Component Analysis (PCA) method. The intuition of PCA is to reduce dimensions in the data to a common pattern; for macroeconomic data that is the business cycle.

The second inherited vulnerability is short economic series which is a frequent problem when working with macroeconomic data. Different approaches may be used which I will discuss more in the construction of the indicators. The PCA methods solves the problem of short time series in a way, by compensating time for larger quantity of economic series, which reduces the risk of bias from one incorrectly chosen series. Thus, comparing the new ALI to the data driven indicator can help to identify weaknesses in the ALI as well as in composing a useful indicator itself. The drawback of the data driven indicator is its non-transparent extraction processes, which make it difficult to assests its validity. Unlike for the ALI indicator where series can be added to the indicator upon availability, using the PCA implies one starting point for all series with the implication of necessary exclusion of important

series in case they are short.

The research question of this paper is

Can an indicator developed following the existing framework of the indicator ALI, developed by de Bondt and Hahn, successfully forecast the Swedish business cycle? How does the result compare to a data driven indicator using a common component analysis?

Because Sweden is similar to the Euro Area and is also connected politically and economically to the European Union (EU), it's reasonable to expect that the framework developed by de Bondt and Hahn to find an indicator for the Euro Area is also suitable for developing an indicator for the Swedish business cycle. The main difference between the Euro Area and Sweden is that the Euro Area consists of 18 countries – economies that have their own business cycle, which can be very different from the aggregated business cycle, whereas Sweden is only one economy with one business cycle. A macroeconomic shock of the same magnitude for the two regions is likely to affect their business cycles differently. Whereas the shock may cancel out in the aggregated Euro Area it may cause a large jump in the Swedish business cycle. However, it is reasonable to anticipate a successful result for an ALI Sweden indicator, because the series included in the indicator will be selected based on the correlation to the reference cycle that the indicator is meant to forecast. For ALI Sweden that would be the Swedish business cycle. The only limitation would be in the case where only very short macroeconomic series would pass the criteria to fit in the indicator, because it would reduce the chance of selecting the real important series due to spurious correlation problems.

The purpose of this paper is to develop an ALI indicator for the Swedish business cycle (ALI Sweden). To do so, ALI orig will be replicated for the Euro Area using de Bondt and Hahn's construction procedure in terms of data treatment and series included in the indicator. If the replicated ALI is successful in terms of reproducing the ALI orig, an ALI Sweden indicator will be constructed using the same procedure but with series selected to lead the Swedish business cycle. Two possible improvements will be considered: an alternative reference business cycle and another filtering method than used in ALI orig. The new indicator will be compared to a data-driven indicator which has a minimum of subjective elements. All data used in the replication are from the International Monetary Fund (IMF) and Eurostat. Data used to create indicators for the Swedish economy are from Statistics Sweden, The Swedish National Institute of Economic Research (NIER), Sweden's central bank

Sveriges Riksbank, IMF and Eurostat.

The paper is organized as follows. To begin with, a brief background of other indicators will be presented in Section 2. In Section 3 follows a discussion on modeling with business cycles, an introduction to filtering methods, an introduction to the concept of Principal Component Analysis, the evaluation methods and lastly the criteria on which ALI Sweden is derived from. Thereafter follows the exploratory part of the paper, Section 4, which includes: replication of ALI, developing ALI Sweden and developing the data driven indicator. All indicators will then be evaluated and discussed in Section 5, and lastly follows Section 6 with conclusions and policy recommendations.

2 Background

Now follows a brief overview of the most common indicators used today in economic forecasting. For the Swedish business cycle, today's most used leading indicators are: *Purchasing Managers' Index (PMI)*, the Swedish central bank's (Riksbankens) indicator of resource utilization (*RU*) and several confidence indicators produced by the [Swedish] National Institute of Economic Research (*NIER*). *PMI* is a monthly indicator derived from surveys made on the private business sector constructed by *Silf*¹ and the Swedish bank *Swedbank*. The surveys include questions concerning new orders, hiring plans, production levels and stock status. The answers are thought to represent the industries' beliefs in the economic future. To capture private consumers' beliefs in the economic future, *NIER* conducts monthly surveys with private people about their expectations on for instance their personal finances, Sweden's economy and changes in interest rates, inflation and wages. The confidence indicators are often used to forecast household behavior, primarily private consumption. In addition to indicators derived from several sources, there are also many indicators equal to just one economic series. Some of the most common single macroeconomic series used as indicators are: *Industrial production*, which indicates the current state, *5-year government bond yields*, *finished goods stocks* and different share price indices, all of which leading indicators. So far, all mentioned indicators are limited to either one economic area or either the production or the consumption side. But in a PCA setting, Riksbanken combines labor market data and survey data on resource utilization into one indicator, the *RU* indicator. *RU* measures the intensity to which firms utilize their employees; more hours worked per employee may indicate prosperity

¹Silf is a Swedish member owned organization which provides development services for purchasing, sourcing and supply professionals for their members

and the stage before more hiring, although RU itself is not forward looking (Nyman, 2010). This indicator provides a more general picture than the other indicators mentioned because it combines information from both surveys and data. However, it's still limited to one economic area although its interpretation may go beyond the labor market.

For the EURO area business cycle, there are several indicators that combine data from different economic areas which form broad economic indicators. The indicator *EuroCOIN* combines information from surveys and financial variables in a PCA setting and exists for both short and medium to long run GDP growth. The EuroCOIN is released monthly by CEPR (Altissimo et al 2001 and 2007). The *Global business indicators* are developed and monthly released by the The Conference Board which is a Global (American based), independent business membership and research association, working in the public interest. The indicators are released for 12 countries and for the Euro Area. The Euro Area indicator consists of seven components² to give a general picture of the business cycle's state and is presented in index form (in levels and growth rates) i.e no filtering method to separate business cycle from the underlying economic trend is applied. Another group of indicators is the Composite Leading Indicators (CLIs). The CLIs are developed and monthly released by the OECD for all OECD countries and for nine zone aggregates, whereof one is the Euro Area. A national indicator consists of relevant macroeconomic series for the specific economic area and is filtered by a double sided HP-filter³. The CLI for the Euro Area leads the reference cycle by six months.

ALI orig is a weighted index of nine economic series and, similar to the Euro area CLI, leads the reference cycle by six months. Unlike the *Global business indicators* but similar to CLI, ALI orig is filtered from both underlying trend and noise. This implies that it's much easier to interpret the ALI predictions compared to, for example, Global business indicators which are presented in level or change in its full series.

ALI's empirical performance has shown to be very accurate and provide early indications of turning points in the Euro Area economy. de Bondt and Hahn show in their paper from 2010 that although ALI and CLI provided similar signals, they

²The seven components are: Economic Sentiment Index, Index of Residential Building Permits Granted, EURO STOXX Index, Money Supply (M2), Interest Rate Spread, Eurozone Manufacturing Purchasing Managers Index, Eurozone Service Sector Future Business Activity Expectations Index

³For the Swedish business cycle, the CLI consists of five series: Overtime hours worked mining and manuf, (%), New orders mining and manuf. sa (base year 2010), Order books(manuf.): level (% balance), Finished goods stocks (manuf.): level (% balance) inverted, AFGX share price index sa (base year 2010)

also behave very differently at certain points in time. Prior to the financial crisis in 2008, both indicators signaled a downturn in the Euro Area. However whereas ALI indicated a slowdown in the economy already in February 2007 and confirmed this picture also in May and August 2007, CLI didn't. Both indicators signaled downturn in November 2008 but CLI much flatter than the more accurate predictions by ALI⁴.

To sum up, there are many useful economic indicators. For the Swedish business cycle however, economic indicators are often limited to either one economic area, are for the current state or lack filtering. The only comprehensive indicator for the Swedish business cycle is the CLI indicator for Sweden. For the Euro Area, the ALI indicator outperformed the CLI Euro Area. An ALI indicator predicting the Swedish business cycle would be a great resource in economic forecasting.

3 Methodology

3.1 Modeling with business cycles

Reference business cycle In order to construct a leading indicator of the business cycle, a reference cycle is needed to serve as a benchmark to which the indicator is constructed to lead, henceforth called Business Cycle Indicator (BCI)⁵. Because of the use of BCI in the construction process of the indicator, the choice of BCI is essential for the final indicator.

Gross Domestic Product (GDP) would be the natural choice because it's through GDP we define economic activity. However GDP is only released on a quarterly basis, whereas we seek to construct an indicator which is quick to discover changes in the economy and therefore, a monthly indicator is preferable. One approach would be to interpolate GDP between the quarters to obtain "monthly data" but at the cost of lower resolution. Such approach may impact which series are selected to the indicator with a bias toward series with larger waves. A second approach is to use a monthly series as a proxy for GDP. The most common series as GDP proxies are: Total production index, service index, volumes of sales of the manufacturing, wholesale and retail sector indices. The reference cycle used in ALI is the Industrial Production Index (excluding construction), which has a correlation of 0.8226 to the GDP of the Euro Area. The same variable will be used in the replication.

However for the ALI Sweden indicator, an alternative BCI for potential improvement will be considered. The largest share of Swedish economy today consists of

⁴see (de Bondt and Hahn, 2010) for details and more information.

⁵in the literature sometimes also called Target cycle or Coincident index

services. Therefore the Service Production Index will be considered in addition to the Industrial Production Index used in the original ALI.

Industrial Production Index and Service Production Index The series Industrial Production Index (IPI) is based on monthly information from manufacturing, mining, and utilities weighted into one index. For Sweden, the majority of the information on industrial production is derived from information on deliveries using questionnaires, which corresponds to roughly 95 percent of the total added value. The remaining five percent is calculated based on information about quantities produced and the number of hours worked (Statistics Sweden). The data forming IPI is also used in the quarterly calculations of GDP, which makes IPI a suitable proxy for GDP. Construction production, such as housing construction, is part of the production measure IPI. Because construction typically is subject to longer contracts and longer delivery times, excluding the construction part of the IPI is common to avoid lagging effects in the proxy.

The trend among developed economies to move production from manufacturing towards more services is strong, and is very strong in Sweden. In 1970, Sweden's industrial production accounted for 36.7 % of the Swedish GDP and services accounted for 57.2 % of the Swedish GDP. In 1981, industrial production had shrunk to 30.6 % and services increased to 64.7 % of GDP. In 2012, Sweden's industry production had declined further to 27.4 % whereas the share of services continued to rise to 70.8 %. The steady trend of increasing services as a share of GDP calls for an empirical investigation of which reference cycle most accurately reflects the Swedish economy and hence is more suitable for the construction of an indicator for the Swedish business cycle.

Two sets of figures are presented. The first set of graphs examines the service production index and the second set examines industrial production index (excluding construction). In Figure 1, the monthly services production index (SPI) is in blue and quarterly GDP is in red. In graph 1(a), SPI shows a pattern of general comovement with GDP. In graph 1(b) the same series are shown but differentiated⁶ in order to give a closer look at the turning points. A turning point is a change of sign in the derivative, which is when the derivative crosses the horizontal line at zero. In graph 1(b), it's clear that the curves don't cross the horizontal axis at the same time, meaning that the turning points aren't simultaneous, except for at one point in 2003. Another thing to note is the short length of the series. It starts in 2000 which

⁶Since this is monthly data, in practice, the discrete equivalent of a derivative, namely the difference between subsequent points, is used. Hence, the two terms *derivative* and *first difference* are used interchangeably.

gives very few cycles to examine and weakens the reliability, even in the case of high co-movement of the series. We can conclude that, although Sweden's economy to a large share consists of services, the SPI is not a suitable proxy for GDP.

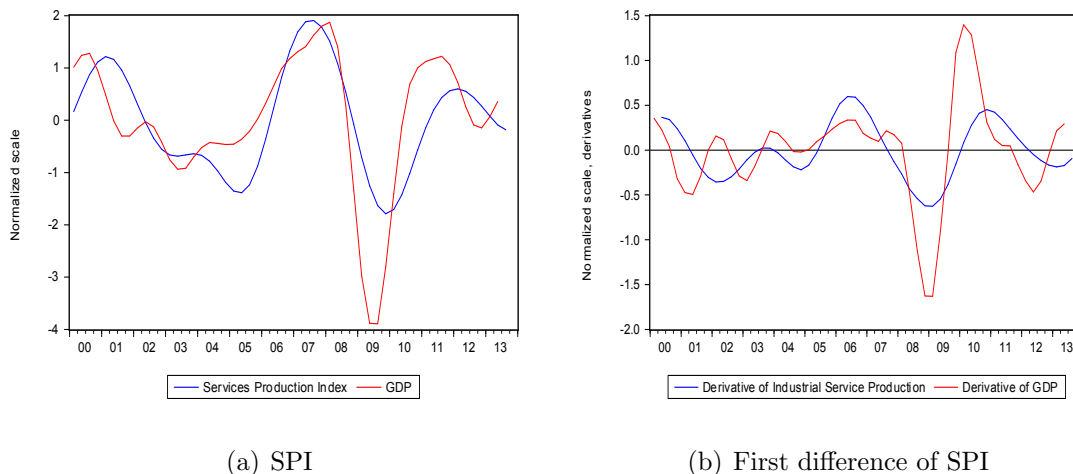


Figure 1: Service Production Index and GDP (series are filtered and normalized to one), as a function of years after 2000. Data from Statistics Sweden.

The second set of figures displays monthly industrial production index excluding construction (IPI-ec) in blue and quarterly GDP in red. Figure 2(a) depicts the series and figure 2(b) shows the derivatives. The IPI-ec series consist of two joined IPI-ec series, merged in 2000, in graph 2(a) marked with a grey vertical line (but not in graph 2(b), due to the dense series). The first series is a backward-calculation by the Swedish statistics agency *Statistics Sweden* and covers the years 1980-1999. The second IPI-ec series begins in 2000 and is still released on a monthly basis by the *Swedish Statistics*. The series consist of the same core components although reservations are issued by the *Swedish Statistics*. The first series (before 2000) share a correlation of 0.74 with GDP and eight turning points (within the same quarter) out of 15⁷. The second series has a correlation of 0.85 to GDP and shares five turning points out of nine. This may seem like a weak fit, however the IPI-ec never turns without the GDP. Thus, GDP is a more volatile series than the IPI series⁸ and

⁷To count a turning points as a *shared turning point*, the derivative has to change to the same sign as well as occur within three months.

⁸the difference in volatility can be due to GDP being quarterly whereas IPI-ex is monthly released, which give different filtering bounds and may affect the filtered series.

because a business cycle has to be at least two years to count as a business cycle, the less volatile IPI doesn't lack any information about the business cycle. Since 2006, the GDP series and the IPI series almost move perfectly together. An additional benefit of the IPI-ec is its relatively long history.

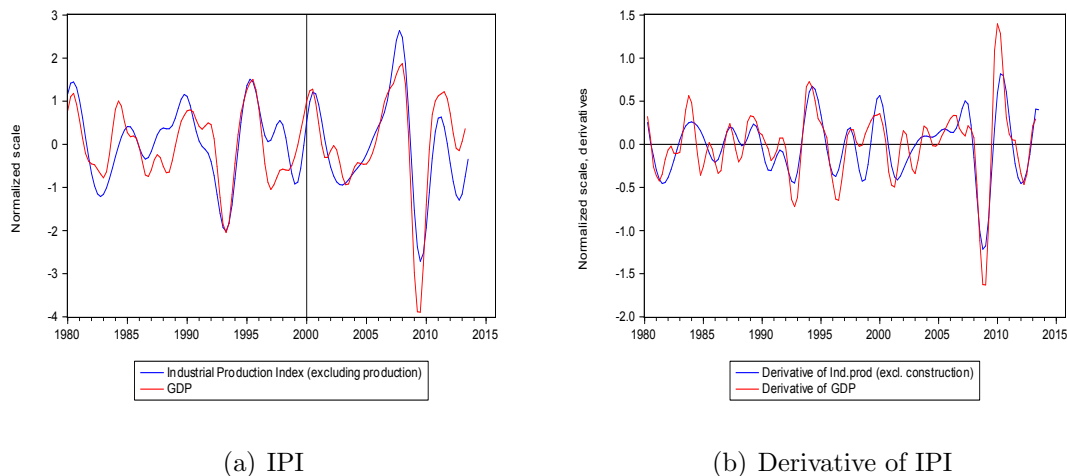


Figure 2: Industrial Production Index and GDP (series are filtered and normalized to one), as a function of years after 2000. Data from Statistics Sweden.

We can conclude that, although GDP consists in large part of services, Industrial production determines the business cycle and hence, IPI-ec is a consistent proxy of GDP whereas SPI is not. Therefore the IPI-ec will serve as the business cycle indicator (BCI) throughout this paper⁹.

3.2 Filtering methods

Burns and Mitchell (1946) were first to develop a thorough definition of a business cycle and how to measure the cycle by extracting it from the underlying growth. They introduced the concept of "deviation from trend" in which economic activity and its tangles of finance is central. To calculate the deviation from trend, Burns and Mitchell estimated a linear trend which they subtracted from the economic series, and were left with the cyclical component. Separating the long run trend from the

⁹There are several more possible reference cycles that the curios may investigate.

business cycle improved evaluation of the economic state in a whole new way which provided much more accuracy than before. Burns and Mitchell's de-trending method was widely used until the 1980s and improved economic forecasting as well as fiscal policy considerably. However the calculations were complicated to perform because they required a lot of knowledge about the underlying growth structure. Also, there was a desire to construct a separation method that would allow the trend to be flexible to long run economic changes derived from innovations and other structural changes in the economy.

Thanks to software improvements since the 1980's, many de-trending methods have evolved¹⁰. Today's most common method for decomposing macroeconomic time series is to use a so called filtering method which separate the components based on *frequency*, or in economic terms, separating data based on the number of *cycles per period*. The key point is that an underlying cyclical behavior shows up as a certain common frequency in the data series. Generally speaking, a trend in data can be seen as a very slow-moving cycle, corresponding to low frequencies. Similarly, fluctuations on a short time scale have a high frequency.

3.2.1 Ideal Band-pass filtering

In short, the ideal band-pass filter is a linear transformation of the data and lets predetermined frequencies through while blocking others.

To separate data based on frequencies, the data is transformed from the time domain to a frequency domain via a Fourier transformation. A range of frequencies, a band with an upper and a lower limit, is set in the frequency domain. All frequencies outside the range are rejected in the ideal band-pass filter. The data can then be transformed back to the time domain and be a series based on the exact defined frequencies. Band-pass filtering became first commonly used in electronics, atmospheric sciences and other science data that experience cyclical movements. Similar to many natural sciences, macroeconomic data also consists of cycles with different frequencies. Granger (1966) was one of the first to introduce the concept of band-pass filtering in economics in order to separate high frequency waves (the business cycle) from longer waves (underlying economic growth, trend) in the data.

However for the ideal band-pass filter to exist, the Fourier resolution has to be infinity large, which requires signals of infinite extent in time. This is never the case, neither in natural sciences nor for macroeconomic series. Therefore other methods to filter the data is warranted. Three of the most renowned approximations developed

¹⁰see for example: Beveridge and Nelson (1981), Blanchard and Quah (1989). Nelson (2008). Fernandez-Villaverde (2005).

for macroeconomic data are: the *HP-filter*, named after its constructors Hodrick and Prescott (Hodrick and Prescott, 1997); the *BK-filter*, developed by Marianne Baxter and Robert G. King (1999), and the *RW-filter* (thus called because of its random walk construction), developed by Lawrence J Christiano and Terry J. Fitzgerald (1999, published in 2003).

The HP-filter is a minimization problem which makes decomposition based on rates of change. The two other approximations are both band-pass filters which employ frequency domain analysis and develop moving averages approximations. They are both widely known for their good performance. The RW-filter is an extension of the BK-filter but uses a slightly different objective function than used in the BK-filter.

Here follows an introduction to the Hodrick-Prescott filter and the two band-pass filter approximations as well as a discussion on their advantages and drawbacks, and on the choice of filtering method for the Swedish ALI and the data-driven indicator.

3.2.2 Some vocabulary

Leakage refers to when the filter lets frequencies through which were meant to be suppressed by the filter. Compression, conversely, refers to when the filter blocks frequencies that are supposed to pass. All filters have some degree of leakage or compression since the cut-off region is not infinitely steep due to the adjustment to finite data.

The problem of *end-point bias* arises when a moving average reaches the ends and there is no more data to use in the calculation and therefore the terminal data point will be given disproportionately large weight. In an ex-post business cycle analysis, this issue is not a major problem since the last observation can simply be excluded prior to the analysis. However in forecasting and analysis of the current time, the end-point bias is a big concern¹¹.

Slutsky (1935) showed that, applying a moving average to white noise series will make the series serially correlated and produce periodicity approaching that of sine waves. This is what is called *spurious cycles* and exists in many filters but more prominently in some filtering methods.

A *phase shift* refers to a shift in the cyclical component, i.e that the shifted component will cross the time axis before or after the true cyclical component.

¹¹One possible solution to the end-problem is to extend the series end(s) with an ARIMA forecast (Kaiser and Maravall, 1999 and Denis et al, 2002). This procedure adds however one more dimension of uncertainty to the final forecast.

3.2.3 Hodrick-Prescott

The Hodrick-Prescott filter (HP-filter), launched in 1980¹² and then empirically derived from American post-war data in 1997, is perhaps the most known and used filter in modern economics (Ravn and Uhlig, 2002).

The HP-filter is a two-sided moving average filter and is constructed as a minimization problem. The purpose is to extract a trend that accounts for different underlying growth rates in different periods of time, see Appendix 7.1 for mathematical intuition. A smoothing (or penalizing) parameter, λ , is set to determine how much the trend is allowed to vary with the cycle¹³. Also, λ controls the location of the cut-off point on the frequency axis, which has implications for the degree of leakage and compression (Pollack 2000)¹⁴. However for all λ , The HP-filter has a high degree of leakage and cycles outside the target region can be substantial, because of its relatively flat cut-off region. This problem aggravates for short time series (see for instance Otsu, 2007; and Iacobucci and Noullez, 2005).

It also suffers from endpoint bias due to its moving average structure. Also, the filter will be revised when new data are added to the sample which complicates comparison and real time analysis over time. Spurious cycles is a common problem in the HP-filter¹⁵. Also, since the HP-filter is a high-pass filter, irregular rapidly moving components will be left in the cycle after filtering. This makes the cyclical component noisy which complicates the interpretation of the business cycle. One may apply a moving average to smoothen the noise, however this is a statistical intervention rather than derived from knowledge of business cycle behavior. A thorough discussion on these two issues can be found in Kaiser and Maravall's paper from 1999.

The HP-filter is symmetric and therefore it induces no phase shifts (Pedersen, 2001). The filter is also attractive for its understandable, transparent construction

¹²The basic method to filter using a minimization problem originates from much earlier work. In 1923, Whittaker applied a similar filtering method in actuarial science, a field in which the method is still being used (Whittaker, 1923). Also Wiener (1949), Whittle (1963) and Bell (1984) contributed to this literature. Their results are in general however only valid for infinite time series and they all relate to the series' midpoints in the filtering procedure.

¹³The higher λ is, the straighter the trend will appear, and consequently, a lower λ will lead to a greater variation in the trend.

¹⁴Based on empirical observations from post-war American data, Hodrick and Prescott (1997) find that the optimal λ is 1600 for quarterly American data. For non-quarterly American data, the setting of λ is debated. See for instance Dolado et al, 1993; Ravn and Uhlig, 2002; Baxter and King (1999). Because no consensus exist, it's common to use the rule of thumb setting of raising the number of periods in a year by two and multiplying that number by 100

¹⁵Cogley and Nason (1995) show that the HP-filter finds a cycle from a random walk with drift series.

and widely recognized performance.

3.2.4 The Baxter and King filter

The Baxter and King (BK) filter is a band-pass filter approximation of the ideal band-pass which formulates the de-trending problem in the frequency domain. Baxter and King have shown that under certain conditions, the result from applying an ideal band-pass filter can be obtained by an infinite moving average. Thus, filtering ultimately takes place in the time domain similar to the HP-filter. Similarly to the HP-filter, the BK-filter is a symmetric moving average which gives the desired property of no phase shifts but leads to information loss in the ends of the sample. For a mathematical intuition, see Appendix 7.1. The major advantage of the BK-filter is its relatively low degree of leakage and compression and no phase shifts.

3.2.5 The Christiano and Fitzgerald filter

The Christiano and Fitzgerald random walk filter (RW-filter) is an extension of Baxter and King's (1999) work in the search for the optimal approximation of the ideal band-pass filter. The RW-filter is based on the same principles; it formulates the de-trending problem in the frequency domain and is a band-pass filter. All properties for the BK-filter hold for the RW-filter. The main difference of the RW-filter compared to the BK-filter is its random walk structure in the moving average calculation which allows dropping the stationarity and symmetry conditions (Iacobucci and Noullez, 2005). The random walk structure gives the benefit of a full sample, and no observations are lost in the ends of the filtered data series, which also implies that the RW-filter doesn't suffer from end-point bias. Therefore the RW-filter is very suitable for forecasting, where the last observation is highly valued. Because the stationary condition is dropped, all data containing a unit root have to be stationary prior to filtering¹⁶. Christiano and Fitzgerald provide a one-sided version of the filter, which is very beneficial for forecasting since the filter will not be revised when new data are added to the series. The drawback of opening up for asymmetry is that it also implies to open up for phase shift.

3.2.6 The choice of filter for this study

The one sided RW-filter is used in the construction of ALI (de bondt and Hahn, 2010), and will hence be used in this study's replication of ALI. For the Swedish ALI and for the data-driven indicator, the choice of filter is open for possible improvements.

¹⁶which can be done by for example logging the series with unit root.

Because all filtering methods have their pros and cons and no method is the correct choice, this study will follow Woitek’s (1998) pragmatic advice of comparing the outcome from different filtering methods. The outcome of HP-filtered data and one sided RW-filter data will be compared.

The RW-filter is a natural candidate because of the desirable properties outlined above. Iacobucci and Nullez (2005) argue that the RW-filter should not be used due to the risk of phase shifts, however in this study, after filtering, every series is matched against a reference cycle and then phased into the ALI indicator depending on its lead. A small global shift of the series, a lead or lag, is therefore not a major issue for this particular study.

Although leakage is a failure in terms of emulating the ideal band-pass filter, a small leakage can help to capture the business cycles outside the target region when the periodicity setting doesn’t capture the actual cycle. As mentioned before, the HP-filter has a high degree of leakage and thus captures this feature. Furthermore, acknowledging the HP-filter’s major recognition and usage, applying the HP-filter opens up for comparisons with other studies.

For the smoothing parameter λ in the HP filter, the rule of thumb setting will be applied in this study¹⁷, which for monthly data is 14400. Because the HP-filter is a high-pass filter and lets through not only the cycle but also all irregular components with high frequencies, a (centered) moving average of four months is applied to the final indicators and the BCI, in an attempt to smoothen out the small fluctuations (high frequencies) and make it easier to see the business cycle.

For the RW-filter, a lower and upper periodicity of a business cycle has to be chosen. For American data, the standard is to follow Burns and Mitchell’s suggestion of one to ten or twelve years. For the Euro Area business cycle, Agresti and Mojon (2003) have shown that a lower bound of 24 and an upper bound of 120 months is optimal. Because the Swedish business cycle share more similarities with the Euro Area than with the American business cycle, Agresti and Mojon’s (2003) recommendation of 24 to 120 months will be used in this study.

3.3 Principal Component Analysis

The DDI is introduced into this paper in order to investigate ALI in comparison to a data-driven indicator. ALI consists of nine series derived from a selection process whereas the DDI forms the indicator in a statistical process based on a large pool of data without further interference by the constructor.

¹⁷Rule of thumb setting: raise the number of periods in a year by two and multiply that number by 100, for monthly data that this: $100 * 12^2 = 14400$.

In macroeconomic forecasting, Principal Component Analysis (PCA) is a popular forecasting method because it covers a large number of series which improves the forecast's accuracy. Other statistical, more traditional, models such as multivariate vector autoregressive models or univariate autoregressive models have limitations when it comes to covering a large number of series.

Mathematically, PCA is a statistical procedure for dimensionality reduction. It explores the correlations in a data set to maximize the amount of information one can extract. Intuitively it can be thought of as projecting the multidimensional data onto those axes which have the largest correlation (and thus variance or spread). A maximal use of the correlations immediately implies that the axes are orthogonal. This is thus an orthogonal linear transformation of the data coordinate system.

In practice, these axes are found from the eigenvalues and eigenvectors of the data covariance matrix. The eigenvectors are orthogonalized, which implies that there can be at most as many eigenvectors as there are data dimensions, i.e., as the number of variables or measurement series. Equation 1 describes the projected coordinate y_{it} (in the new basis) of measurements \vec{x}_t using the principal components \vec{p}_i :

$$y_{it} = p_i + p_{i1}x_{1t} + \dots + p_{iK}x_{Kt} \quad (1)$$

The first principal component (PC), p_{i1} , is the linear combination which captures the greatest share of variation in the data set. The second PC captures the second greatest share of the variation and is linearly independent on the first PC. The same logic is applied for the third PC and so on (see for instance Harman, 1976 and Johnson and Wishern, 1992). In a pool of macroeconomic series, the first PC is the business cycle.

When extracting the PC, information that is not part of the shared motion is removed. Therefore there will always be information lost, however, according to Johnson and Wishern (1992), almost no information loss will occur by using PCA for dimensionality reduction if 1) the amount of variables is sufficiently large and 2) all the variables can be attributed to the first, second or third components¹⁸.

3.4 Evaluation methods

In Section 5, the indicators' performance will be evaluated. In addition to turning points analysis, the standard evaluation measures for economic forecasts will be employed. The standard measures assess bias, accuracy and efficiency. It's also

¹⁸For a full explanation of the Principal Component Analysis, please read *Handbook of Economic Forecasting* edited by Graham Elliott, Allan Timmermann, Volume 2, Part 2, chapter 4.1.

standard to include some kind of naive forecast comparison, which will be followed in this study.

Accuracy The three most common measures of predictive accuracy in ex-post forecasting evaluation are: The Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Theil’s inequality coefficient U (Theil’s U) (Fair, 1986).

The two economists Meese and Rogoff showed in their famous paper from 1983, that a simple random walk model actually often outperformed economic forecasting models in predicting exchange rates (Meese and Rogoff, 1983). It has since then been standard to include some sort of naive forecast as a benchmark. If the indicator does not beat the the naive forecast, then it can be considered as being not any better than guessing and hence useless as a credible forecasting tool. In this study, a naive forecast comparison is employed using the Theil’s U formula¹⁹. In order to beat the naive benchmark, Theil’s U has to be less than one (the numerator is smaller than the denominator). If Theil’s U is one, then the forecasting method is exactly as good as a random walk. Consequently, greater than one indicates that guessing is better than the forecasting model.

RMSE represents the deviation between the forecasted values and the observed values²⁰. It’s the root of the sum of the variance of the residuals squared, which penalizes large forecasting errors more than small errors.

MAE²¹ is very similar to RMSE but the formula doesn’t penalize large errors, which makes it a suitable measure in the case where large errors are not considered

¹⁹The Theil’s U formula:

$$U = \sqrt{\frac{\sum_{t=1}^{n-1} \left(\frac{Y_{t+1} - \hat{Y}_{t+1}}{Y_t} \right)^2}{\sum_{t=1}^{n-1} \left(\frac{Y_{t+1} - Y_t}{Y_t} \right)^2}}, \quad (2)$$

where Y_t is the actual business cycle for a given time period t , n is the number of data points and \hat{Y} is the forecasted business cycle.

²⁰

$$RMSE = \left(\frac{1}{N} \sum_{i=1}^N e_{i+h|i}^2 \right)^{\frac{1}{2}}, \quad (3)$$

where is the e is the forecasting error and N is the number of observations.

²¹

$$MAE = \frac{1}{N} \sum_{i=1}^N |e_i|, \quad (4)$$

with the same notation as in Eq 3.

to be any worse than small errors. Both the MAE and RMSE measure serve to aggregate the magnitudes of the errors into a single measure of predictive power and both should be as small as possible.

Bias For a forecasting model to be unbiased, it can't consistently under- or over-estimate the actual observations. The Mean Forecast Error (MFE)²² measures the average bias. The ideal value is zero which equals zero bias. If MFE is positive (negative), it means that the forecast tends to underestimate (overestimate) the growth of the business cycle.

Efficiency To test the efficiency, the following simple regression is conducted:

$$FE_{t+k} = \beta_0 + \beta_1 RU_t + \eta_{t+k}, \quad (6)$$

where the forecast efficiency FE is $(BCI_{t+1} - Indicator_{t+1})$. The variable RU is Sweden's central bank's (Riksbanken's) resource utilization index. Because RU was in the information set at time t , efficient use of data requires that RU cannot explain variation in the forecast error. The null hypothesis is: $H_0 : \beta_1 = 0$ and tested using a standard t-test with Newey-West standard errors. For the forecast to be efficient, the null has to hold.

3.5 Series Selection Criteria

To find the series that will constitute the indicator, de Bondt and Hahn use a general-to-specific approach. They start out from a large pool of macroeconomic time series on which they test three criteria. These are:

ALI Original Criteria

- Criterion 1: The series should lead the reference business cycle and have a correlation with the business cycle by at least 0.6.
- Criterion 2: The lead time of BCI has to be at least five months and the lead should be stable over time.

²²

$$MFE = \frac{1}{R} \sum_{n=1}^R e_{n+h|n}, \quad (5)$$

where R is the number of observations and e is the forecasting error, or discrepancy between the forecast and the reference cycle.

- Criterion 3: The indicator should consist of a mixture of series that together form a broad based indicator covering the relevant economic areas.

(p 16-17, de Bondt and Hahn, 2010)

The criteria will not be applied in a general-to-specific process for the replication of ALI, yet the purpose of the replication is not to check their work but to ensure that the working procedure complies with de Bondt and Hahn's working procedure (filtering etc). Therefore the objective is to find series that are to the largest possible extent the same series used in the original ALI.

For the creation of ALI Sweden, the criteria will be used on a pool of data adjusted for the Swedish business cycle. Economic time series for Sweden are in general shorter than the series used in de Bondt and Hahn's work. Applying the original full criteria would exclude many valuable series from the indicator. Therefore the criteria are adjusted taking into account the trade-off between long series and valuable short series. The second criterion requires "stable lead", which for the Swedish business cycle may sometimes mean a stable lead over 15 years, whereas this criterion implies 25 years of stable lead in de Bondt and Hahn's study. Short data series rise the concern of spurious correlation; a series with high correlation with BCI but only available for a few years doesn't necessarily predict future GDP better than a series with slightly lower correlation to BCI which is stable over a longer period of time. The high correlation for the short series may be driven by a specific event in the economy that may never come back. On the other hand, many young series are very good at predicting the business cycle today and should not be excluded only because they cannot show a long history of stable lead. This is a trade-off between certainty derived from long stable lead and valuable information from young data series. The year 2001 will be used as the lower limit; no series that begins later than 2001 can be part of the indicator. Younger series than 2001 may be biased from the financial crisis in 2008 where all series show decline, even the less sensitive ones. Criterion 1 is modified as follows, in order to be applicable to the Swedish business cycle:

- Criterion 1: The requirement of average correlation is changed from 0.6 to 0.5 if the series is "long" (begins before 1980). The correlation during the period 1990 until today should still be 0.6 in order to qualify into the indicator. Exceptions may occur, with the lower limit of 0.55, if the series is important for the mixture of economic areas.

Concerning criterion 3, how do we know when a good mixture of series is found, which series form a broad based indicator? Neither exist any official guidelines on

which economic areas are the most important nor do de Bondt and Hahn provide guidelines. Considering the driving forces in a modern economy as well as which economic areas move in the forefront, the following economic areas will be used as guideline in order to create a broad-based indicator: the financial market (long and short run), consumers' confidence in the future, business climate (both domestic and international) and lastly, the world economy.

4 Empirical results

4.1 Replicating ALI

As an exploratory step towards constructing ALI Sweden, the original ALI will be replicated using the information available in de Bondt and Hahn's paper. Evaluating the original and the replicated ALI gives insight in how well the replication succeeded and will later serve as a benchmark for ALI Sweden.

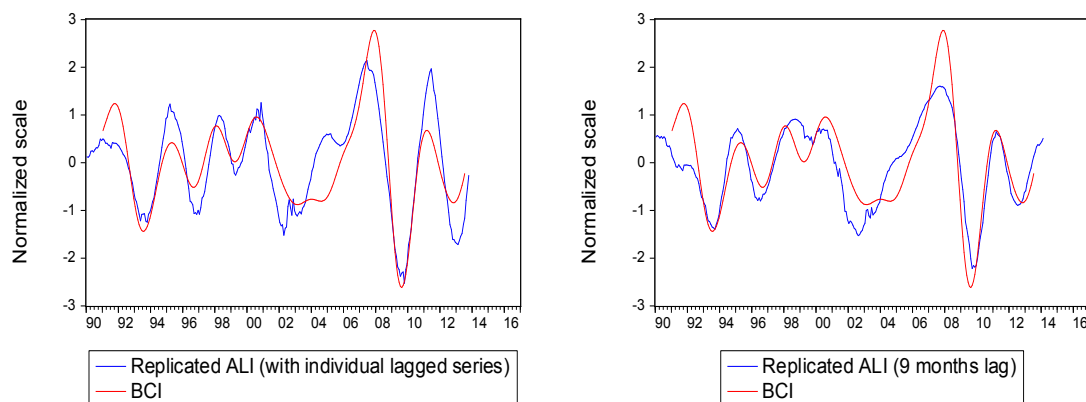
The construction procedure in short: all series (except for interest rates) containing a unit root will be transformed to their natural logarithm prior to filtering. The filter method is the One sided high pass random walk filter with a period setting of two to ten years. The series are then equally weighted into an index and lagged by their lead in order to forecast the BCI. Detailed information about de Bondt and Hahn's methods aren't available for the public²³. Two ambiguities originate from the fact that the series begin at different points in time. One ambiguity concerns the lagging procedure and a second concerns the merging process of the series.

Starting with the lagging process, after the series have been selected they have to be moved backwards in time, "lagged", to co-move with the business cycle and show its prediction where the BCI ends. The lagging procedure can be done in mainly two ways but no direction is given by de Bondt and Hahn in their paper. Either one can merge the series and then assess the composite series' lead against the BCI, and thereafter lag the composite series with its lead. Or, one can start by lagging the individual series with its individual lead to BCI and then merge the series into one composite index. A joint lag implies that the average lag of the composite series and the new series is used. For instance, if an interest rate leads BCI by 12 months and the composite index leads 8 months, the merging point will show contra cyclical information. Therefore only individual lagging can theoretically be correct however the joint lag may turn out to work empirically well. In the case where the indicator consists of series with mostly the same leads of the BCI, a joint lag may be as good

²³The authors have been contacted in an unsuccessful attempt to gain more information.

as individual lagging.

This is illustrated in the two following graphs in Figure 3. Graph 3(a) shows ALI with individual lags (the intuitively construction) and BCI. The second graph shows ALI constructed with one common lag of nine months and the BCI. The first thing to note is the indicator's different lead of BCI. ALI with individual lags leads BCI with only three months whereas ALI with a common lag leads with as much as nine months. Until 2006 the two ALIs perform about the same and after 2006, they perform almost identically. Thus, empirically it seems like no significant bias has been introduced by using a common lag. But theoretically we know that the ALI with the common lag contains different leads however only one is considered. Ignoring the different lead times can at worst lead to contra cyclical behavior among series which can make the indicator behave oddly. In this particular case, the government bond is shifted a full cycle which gives a good looking result and a long lead, but which is more fortunate than justifiable. After all, we don't know which lagging approach is used in the original ALI.



(a) Replicated ALI individually lagged series (b) Replicated ALI with one nine months lag

Figure 3: Comparison of lag procedures in replicated ALI.

Concerning the merging process, one can either use series that are long enough to avoid merging at different points in time, or the series can be merged upon availability. As mentioned earlier in this paper, because macroeconomic series are often short, excluding short series would limit the selection group tremendously. Therefore it will be assumed that de Bondt and Hahn have employed a merging upon availability strategy. The merging process will however introduce discontinuities in

the composite series if the merged series are on different magnitudes at the merging point in time; the new merged data point will be an average of the points of the composite index and the new series. Although the discontinuities are created in the statistical procedure, they may incorrectly look like turning points in the business cycle. The discontinuities are in general small and will only exist to the point where all series are included in the index. Once can investigate these possible discontinuities by assessing the series in percentage change and the merging points after the lagging procedure. Because it is not meaningful to assess turning points before all series are included, no such analysis will be conducted in this study.

4.2 Comparing the replicated ALI to the existing ALI

All nine series which form ALI and their lead of the BCI are presented in Table 1. The second column shows the leads of the original ALI and the third column shows the lead found in the replication. For the replication to be successful, the lead of the original and the replicated ALI should not be substantially different without reasonable explanation.

Series name	Original ALI	Replicated ALI
German 10y gov. bond yield (nominal, inverted)	24	21
Stock price index (nominal)	6	3
US unemployment rate (inverted)	5	2
M1 (real)	11	15
German IFO (business expectations)	8	7
Building permits in the euro zone	13	5
Economic sentiment indicator	5	5
Consumer confidence indicator	5	4
PMI manufacturing new orders-stock ratio	9	8
ALI ind.lagged series	6	3
ALI composite lag	6	9

Table 1: Lead time with respect to BCI of the series included in ALI orig and the replicated ALIs

Considering that the leads in the original ALI go back to 1970 ,whereas the series in the replicated ALI start in 1990 (due to short IPI series), the leads in the replication are in general consistent with the original leads. However, three series show very

different lead from the original series: stock price index (differs 100%), US unemployment rate (differs 150%) and building permits (differs 160%). The discrepancy is most likely explained by the very different correlation periods examined. Building permits for the Euro zone became public in 2000, which is also the start date for the series in the replication. de Bondt and Hahn have however gotten hold of a series starting already in 1980. This series may be very different to the one which started in 2001. Concerning the stock price index and the US unemployment, de Bondt and Hahn have used the same series as publicly available however because the available IPI series starts in 1990 whereas the IPI series in the original ALI starts in 1970, the examined correlation period is very different. For the series where the time length differences are smaller, the difference in leads are also smaller which supports the replication. Another source for discrepancy between the original series and the series in the replication is data revision. The series that have been subject to revision are: building permits, monetary aggregate M1 and the US unemployment rate.

The original ALI leads by six months whereas the replications lead by either by three or nine months. This is most likely due to the different leads de Bondt and Hahn found in their examination of the individual series.

The next step is to (equally) weight the series together using both the individual lagging technique and the joint lagging technique, to compare the replications to the original ALI indicator. Since the data series of ALI are not publicly available, the best comparison one can do is to compare the graph presented in ALI in de Bondt and Hahn's paper to the replicated ALI. We are interested in examining the general movement and especially the timing of the turning points. Figure 4 show all three graphs, the first being the original graph, the second the replicated ALI using individual lags and the last is the replicated ALI with a joint lag. The colored series are ALIs and the black series are the BCI.

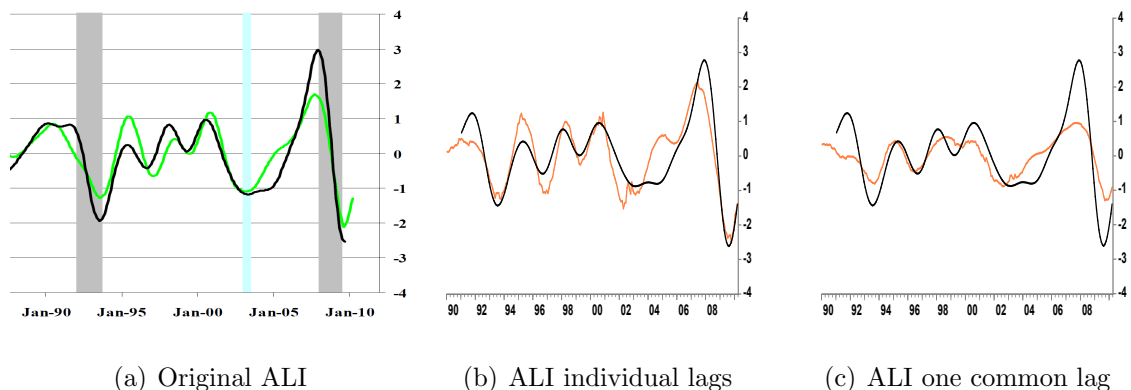


Figure 4: Comparing the original ALI with the two replicated ALI. The time range in the graphs is limited to 1990 to 2009 to match each other (ALI orig covers 1960-2009, replicated ALI 1990- 2013).

All ten turning points in the original ALI are present in both replications and no extra turning points are observed. Also the relative magnitude in the replications matches the original ALI. There is a small difference between the individually lagged ALI and the common lagged ALI during 2004. The individually lagged ALI indicates one additional peak whereas the common lag ALI doesn't, here only growth slows down slightly during the period. The common lag ALI compares better to the original ALI as well as the BCI.

To sum up, there are some differences in lead time between the series in the original ALI and the replicated ALI, but all of which can be explained by the very different examined periods of time. The series with approximately the same investigated period for the original and the replicated, also show consistent lead. The performance of the replicated ALIs are very close to the original ALI. Therefore the working procedure seems to work well, and we can now move on to developing an indicator for the Swedish business cycle, now by using the full method including general to specific, as well as consider some possible improvements.

4.3 Developing ALI Sweden

The same framework as used in the replication of the original ALI will be used to construct the ALI Sweden indicator. The criteria in the previous section will now be used to find the series to develop ALI Sweden. When the series are selected, two versions of ALI Sweden will be created, one filtered with the one-sided RW-filter

and one filtered with the HP-filter. The RW-filtered will be presented whereas the HP-filtered indicator is saved for the evaluation section. To make the most use of the available data, the series will be included upon availability. Therefore the indicators will contain few series in the beginning and nine series in 2001 at the latest. To enable evaluation on a period free from bias derived from the construction process, one year of data is excluded from the construction process and saved for out-of-sample forecast evaluation. Hence the pool of data used in the general to specific process is truncated in July 2013.

Finding the series for ALI Sweden All the series in the general-to-specific process are listed in Figure 5. The second column, C1, shows the average lead between the series and the BCI. Column three, C2, indicates whether the lead is stable: plus sign for yes, negative sign for no and no sign for border line or not relevant because of too low or short lead. The fourth column, C3, indicates whether the series adds any new information to the mixture of series selected for the indicator so far. The remaining columns investigate correlation and lead time for different start years in order to assess the criterion of stable lead. To examine a series correlation to the BCI, the series is first lagged with its lead of the BCI. The last column contains a comment for every series. The nine series in bold are the series finally selected for the indicator. Discussion of the selected series follows after Figure 5. The selected series capture the influential economic areas: the financial market, business climate, private consumption and the world economy.

Financial market The Financial market is directly entangled with the business cycle and responds quickly to changes in the economy, which also makes the financial market affect the business cycle. To include the short run financial market in Sweden, the *OMX index* is included. For the long run financial market, a ten year Swedish government bond and Sweden's money supply *M1* are included in the indicator. The *OMX index* series starts in 1986 and has an average correlation to the BCI of 0.65. Examining only the period between 2000-2013, the correlation is as high as 0.81 which shows the stock market's strong reaction to the financial crisis in 2008. Including the *OMX index* contributes with quick and important information about the financial climate in Sweden but also outside of Sweden. The *10 years government bond* captures the long term risk free rent. The series is long and leads BCI by 23 months. Correlation starts at low correlation (0.4726 for the period 1980-1990) but steadily increases and ends with 0.7119 for the period of 2000-2013. The series *Money supply M1 (yearly change)* captures the transaction motive for holding money. More money in the economy leads to lower interest rate (with a delay) which eventually

Macroeconomic time series Selected series in bold	Correlation		Stable lead		Correlation, sample starting in					Optimal lead (in months), sample starting in					Comments
	C1	C2	C3	mixture	1980	1990	2000	1980	1990	2000	1980	1990	2000		
Building permits Sweden	0.8939 (2000)	+	+	-	-	-	-	-	-	-	-	-	-	4 Series too short	
Building permits Euro Area	0.7624 (2000)	-	-	-	-	-	-	-	-	-	-	-	-	5 captures housing market and future beliefs	
Business Cycle Indicators, United States, Capacity utilization rate, manufacturing	0.7320	-	-	-	0.7320	0.7245	0.7728	0.7320	4	4	4	4	4	4 Stable but short lead	
Consumer Confidence Indicator Euro Area	-0.6400	-	-	-	-0.6400	-0.6881	-0.7289	-0.6881	4	3	3	3	3	4 Short lead	
Consumer Confidence Indicator Sweden	0.7038 (1993)	+	+	+	-	-	-	-	-	-	-	-	-	8 Broad-based composite consumer survey indicator	
Consumer prices, Euro Area	-0.0713	-	-	-	-	-0.0713	0.3293	0.2702	12	0	0	0	0	0 Unstable lead and too low correlation	
Economic Sentiment Indicator Sweden	0.7807 (1990)	+	+	+	-	-	-	-	-	-	-	-	-	6 Stable lead and relatively long series	
Economic Sentiment Indicator world	-0.1695	-	-	-	-	-0.1695	-0.1703	-0.1703	1	2	2	2	2	2 Lead too short, correlation too low	
Government bond 10 years Germany (inverted)	-0.4276	-	-	-	-	-0.4276	-0.4160	-0.3677	23	23	23	23	23	23 Correlation too low	
Government bond 5 years Sweden (inverted)	0.3296	-	-	-	-	0.3296	0.3450	0.3750	22	22	22	22	22	23 Correlation too low	
IFO	0.7648 (1991)	+	+	+	-	-	-	-	-	-	-	-	-	8 High and stable correlation	
KIX	-0.3734	-	-	-	-	-0.3734	-0.3351	-0.5312	0	0	0	0	0	5 instable lead and too low correlation	
M1 (real) Sweden Y/Y	0.7425 (1990)	+	+	+	-	-	-	-	-	-	-	-	-	12 Captures transaction motive for holding money	
M1 Growth rate	0.6242	+	+	+	-	-	-	-	13	13	13	13	13	13 Captures transaction motive for holding money	
OMX index	0.6498 (1986)	+	+	+	-	-	-	-	5	5	5	5	5	4 Captures Swedish equity market	
Ordering, export USA	0.4690	+	+	+	-	-	-	-	8	7	7	7	7	8 Correlation too low	
PMI usa (Manufacturing)	0.3854	+	+	+	-	-	-	-	12	11	11	11	11	11 Correlation too low	
steel production USA	0.6472	-	-	-	-	0.6472	0.7238	0.7886	3	3	3	3	3	4 lead too short	
steel production World (2003)	-0.7527	-	-	-	-	-	-	-	-	-	-	-	-	17 short series and unstable lead	
Sweden Government bond 10 years (inverted)	-0.4726	+	+	+	-	-	-	-	23	23	23	23	23	22 Captures long-term risk free rate	
Sweden, Government Benchmarks, Long Term (Eurostat), Yield, Average, EUR	-0.4438	+	+	+	-	-	-	-	23	22	22	22	22	18 Captures Germany's business climate	
Unemployment (inverted) Germany	0.5909	+	+	+	-	-	-	-	18	18	18	18	18	18 Captures Germany's business climate	
Unemployment EU	0.3761	-	-	-	-	-	-	-	-	-	-	-	-	22 Unstable lead	
United States, Average weekly overtime of production workers, Hours Worked, Average Per Week, Nonfarm pay	0.3939	-	-	-	-	-	-	-	7	5	5	5	5	5 Captures American market, short lead.	
United States, Consumer Prices, All items, Cpi Y/Y	0.6119	-	-	-	-	-	-	-	1	1	1	1	1	1 lead too short	
United States, Leading Index, Average weekly hours, manufacturing	0.6342	-	-	-	-	-	-	-	7	7	7	7	7	5 Captures American market, short lead.	
USA Government bond 10 years (inverted)	0.4119	-	-	-	-	-	-	-	2	2	2	2	2	3 Lead too short, correlation too low	
USA unemployment rate (inverted)	0.7814	+	+	+	-	-	-	-	1	1	1	1	1	1 Lead too short	
Euro Zone, Industry Survey, Total Manufacturing, Production Expectations, Business Surveys, Euro Zone, Balance of Payments	0.2104	-	-	-	-	-	-	-	2	4	4	4	4	5 Correlation too low	
M1 Euro Area	0.4524	-	-	-	-	-	-	-	15	12	12	12	12	19 Unstable lead and too low correlation	
M1 USA currency	0.5468	-	-	-	-	-	-	-	16	16	16	16	16	19 Unstable lead	
United States, Money supply M1, USD	0.5945 (1990)	+	+	+	-	-	-	-	24	23	23	23	23	25 Captures the American inflation	
MCI M1 (american monetary condition index)	0.6195	+	+	+	-	-	-	-	23	24	24	24	24	24 Captures the American inflation	
gov 10 years Taiwan	-0.4478	+	+	+	-	-	-	-	23	24	24	24	24	21 correlation too low	
China, Shanghai SE, Composite Index, End of Period, TWD	-0.5425	+	+	+	-	-	-	-	24	24	24	24	24	25 Captures the Chinese market	
Norway stock index OBX	0.6047	+	+	+	-	-	-	-	23	5	5	5	5	1 Unstable lead	
10 years government bond EURO-area (log)	0.3332 (1990)	+	+	+	-	-	-	-	20	21	21	21	21	19 Captures business climate in the Euro-area for the long run	
PMI = (stock of new orders/ purchases of order)	0.6608 (1994)	+	+	+	-	-	-	-	12	12	12	12	12	13 Captures the Swedish business climate	
PMI New orders	0.6875	-	-	-	-	-	-	-	9	9	9	9	9	9 Captures the Swedish business climate	

Figure 5: General-to-specific selection of series used in ALI Sweden

leads to more investments. The *M1* series starts in 1990 and leads the Swedish BCI by 12 months and has an average correlation to BCI of 0.74, and of 0.80 during the period 2000-2013.

Business climate The *Purchasing Managers Index (PMI)* series exist in 30 countries worldwide and has empirically been shown to be a very good indicator of private sector companies' future behavior. Instead of using *PMI new order*, which is the most used PMI measure, a composite PMI equal to: $\frac{PMI_{new\ orders}}{PMI_{stocks\ purchased}}$ will be used in order to capture also the stock purchased (the existing inventory). The composite PMI starts in 1994, leads BCI by 12 months and has a correlation to BCI of 0.56 during the period of 1990-1999 and 0.66 during the period of 2000-2013.

The *number of building permits issued* in a country indicates the business climate in the building sector. Because the building sector signs medium to long term contracts, the building sector is an informative indicator of future beliefs. The Swedish housing market is however different to many other countries' housing markets in the sense that Sweden has a large share of public housing where the government is the developer. The government tends to build contra-cyclically, unlike the rest of the building sector, which makes the series *Building permits* in Sweden difficult to interpret. Although the *building permits* series for Sweden is not feasible to include, the building sector outside of Sweden, where governments build less, also carries valuable information due to its medium to long run investment scheme. Therefore the series *Building permits* for the Euro Area will be included in the indicator. The series starts in 2000 and has a lead of five months and a correlation of 0.76 to the BCI.

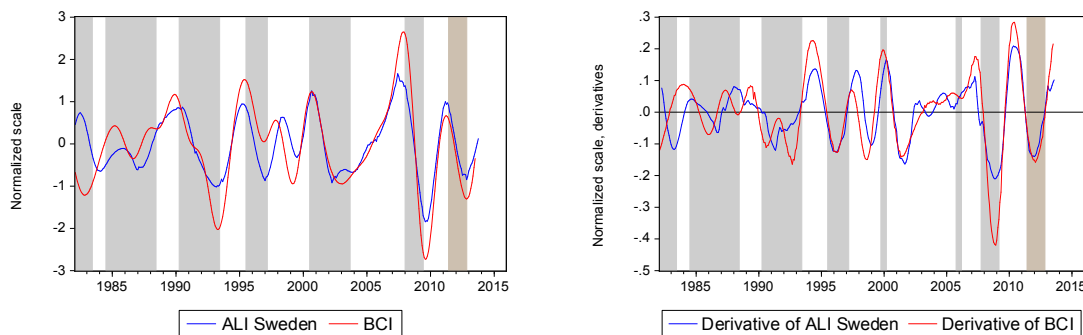
The *Economic Sentiment Index (ESI)* captures the sentiment in services, production, construction and trade. ESI has a stable lead of six months and an average correlation of 0.78 to BCI. Because this variable captures the sentiment in the constructing sector, the inclusion of this variable mitigates the loss of not being able to use Swedish building permits in the indicator.

Private consumption Private consumption is a large part of the Swedish economy. It's therefore very valuable to include information about private people's beliefs about the future which (hopefully) indicate their future consumption levels. If a person estimates her future to be bright, she is more likely to save less and spend more. The *Consumer Confidence Index (CCI)* consists of private people's thoughts about the future. It leads the BCI by stable eight months and has an average correlation of 0.70.

World economy Germany is Sweden’s largest trade partner. A change in the German economy is likely to be transmitted to the Swedish business cycle. Hence the German economy should be included in the indicator. Two series are considered: the *German unemployment* which leads the Swedish BCI by stable 18 months and has an average correlation of 0.6 to BCI, and the series *IFO* which is a business climate indicator for Germany and leads the Swedish BCI by 7-8 months and has a correlation of 0.76. The IFO is finally selected to the indicator because of its higher correlation.

The large economy USA impacts the whole world and so also Sweden. This impact was very prominent during the financial crisis in 2008, a crisis derived from the US housing market. The only series that meets criteria number one and two in this sample is the *American money supply (M1)*. The American *M1* leads the Swedish business cycle by 23 to 25 months and has an average correlation of 0.59, which is considered to meet criterion number two considering its unique contribution to the indicator.

Creating ALI Sweden The left hand figure 6(a) shows the ALI Sweden with the series chosen above, lagged individually. ALI Sweden leads the Swedish BCI by three months. Since we are interested in examining the turning points, the series’ derivatives are illustrated in the right-hand side figure 6(b). For the series to have the same timing, the first-differenced series have to cross the X-axis at the same time.



(a) ALI Sweden (Ind.lagged series)

(b) First difference of ALI Sweden (Ind.lagged series)

Figure 6: RW-filtered. Grey areas indicate recessions according to Swedish Fiscal Policy Council definition (preliminary calculation in yellow-grey).

Examining the derivatives of the indicator ALI Sweden shows 18 turning points whereas the BCI shows 16 turning points. They share ten turning points²⁴. ALI Sweden performs best after 2000 which is also expected because all series are included in the indicator after 2000. After 2000, ALI Sweden indicated all turning points plus a small rapid turn in 2003 which should only have been an inflection point and not a turn according to the BCI.

As discussed in the replication of ALI, the indicator can either be lagged with one lag for the whole indicator (with the indicator's lead to the BCI), or the series can be individually lagged before they are weighted into one index. Graph 7 shows the ALI Sweden with one common lag of 10 months. Comparing to 6(a), which has individual lags, it's clear that one common lag is not the correct procedure. The series have too different lead time which for instance results in a downturn of the indicator in 2013 at the same time as the BCI shows no downturn.

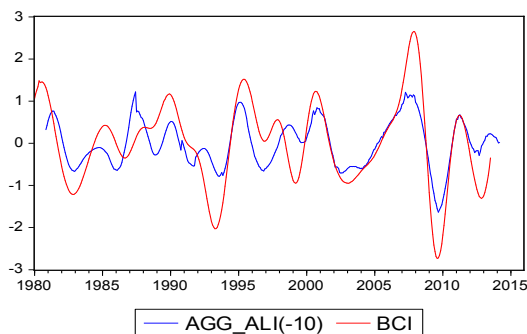


Figure 7: ALI Sweden, one joint lag of 10 months, RW-filtered, normalized scale.

4.4 Developing a data driven indicator for the Swedish business cycle

The first step is to put together a pool of data from which the business cycle can be extracted. This pool should mainly consist of series covering the Swedish economy in order to capture the Swedish business cycle. Down the line, the macroeconomic series for Sweden will contain information about the world economy, but to avoid a lagged response to the world economy, also macroeconomic series covering other economies are added to the pool. These are mainly: the EU/Euro-area, OECD,

²⁴To count a turning point as shared turning point, the turns have to occur within three months. They also have to turn in the same direction.

Germany, USA, India, and China. To improve the lead time of the DDI, the lagging macroeconomic series are kept to a minimum.

The PCA-method can only estimate a common component for continuous series. This implies, unlike the construction of ALI, that the series' full length cannot be used in case shorter series are part of the data pool. The PC-series will start where the shortest series begins. The same trade-off as discussed in the construction of ALI, of finding a balance between long series and short but informative series, applies here too. The limit is set to year 1994; no series starting after 1994 can be part of the pool of data. As outlined in more detail in Section 3.3, all variables have to be able to be attributed to the first, second or third components. Because only the first component is of interest in this study, the threshold is set to the first component in order to capture only the cycle of interest²⁵. In order to avoid revisions due to rebasing of the Consuming Price Index, nominal series will be used when possible.

Applying these guidelines on monthly data available from the data sources Eurostat and IMF, the final pool of data consists of 36 macroeconomic series which gives 160 observations. The extracted PC, from now on referred to as DDI, shown in Figure 8 leads the Swedish business cycle by seven months and correlates with the Swedish BCI by 88% percent. The lead of seven months is lagged in the graphs to enable comparison to BCI. The first graph shows the two series and the second graphs shows the derivative of the two series to facilitate interpretation of the series' turning points. The complexity of lagging the indicator discussed for ALI Sweden doesn't apply here because the PC is ultimately only one series.

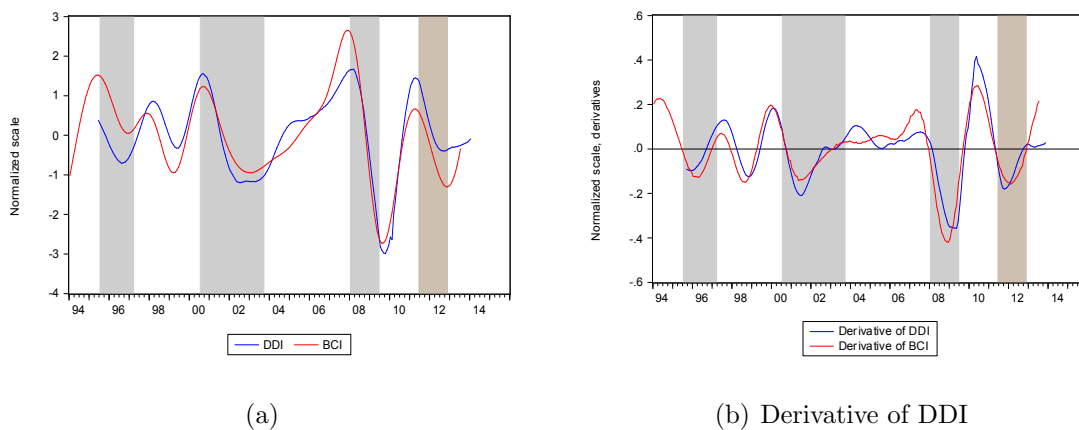


Figure 8: DDI and BCI

²⁵Threshold: loadings smaller than 0.1 are removed from the pool of data

All nine turning points in the BCI are represented in the DDI. In the summer of 2005, the DDI has an inflection point whereas the BCI doesn't. Examining Graph 8, the lead of DDI varies in a range of three to ten months (seven months lead is shown as unison crossing of the x-axis due to the lagging of DDI). The DDI does never turn after the business cycle.

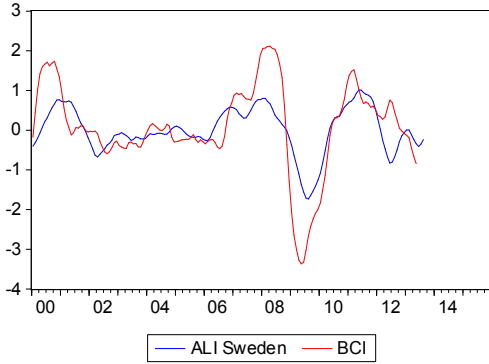
5 Evaluation

5.1 The effect of different filtering methods

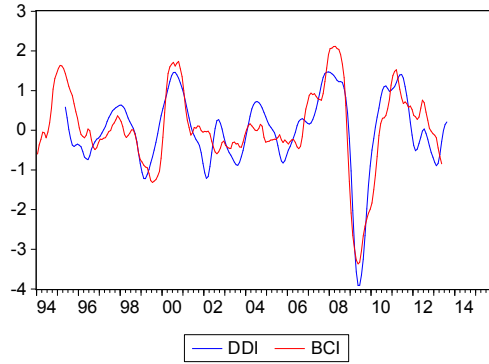
The filtering process of the series affects the final indicators in two respects. First of all, the filtering impacts the selection process in the selection of series to ALI Sweden – and consequently the final ALI Sweden indicator. If the filtering method suppresses a recession in the BCI, only series that also suppress or don't show that specific recession are likely to be considered to be part of the indicator due to the requirement of high correlation to the BCI. The same reasoning is valid for leakage and spurious cycles. Secondly, the filtering process affects what result is obtainable, for instance in terms of smoothness of the series, end-point bias and phase shifts. This section will discuss the filters' limitations in the final result as well as indications of leakage, compression and spurious cycles. In the construction of DDI, the series are not selected based on their correlation to BCI, therefore the choice of filtering method for the DDI is less crucial than for ALI. Nevertheless, the filtering process does impact the final indicator.

Figure 9 compares ALI Sweden (left) and DDI (right) to BCI. Additionally, the series shown in Figure 9(b) and 9(a) are filtered using the HP-filter while the series shown in Figure 9(c) and 9(d) are filtered using the one sided RW-filter. The first thing to note is the different frequency range between the HP-filtered series and the RW-filtered series. Figure 9(b) and 9(a) show many high frequencies (noise) whereas Figure 9(c) and 9(d) appear much smoother. This result is expected because the RW-filter removes both slow moving components (long run trend) and fast moving components in the economy (small fluctuations, noise), whereas the HP-filter only removes the former. A four months' moving average is applied on the HP-filtered series in order to smoothen out noise and visualize the cycles of interest, however the HP-filtered series still contains much fluctuations.

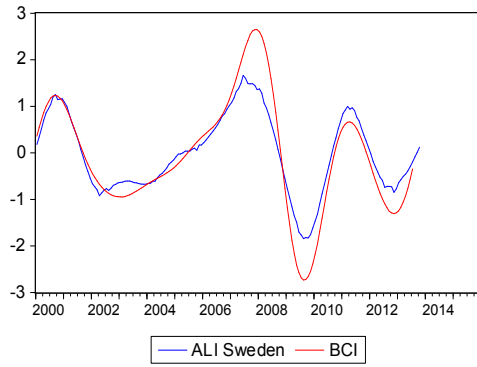
The additional cycles in 9(a) are small and are more likely to be noise than spurious cycles because they last for less than two years. In Figure 9(b) however, several prominent cycles are present compared to the series in Figure 9(d), filtered with the RW-filter. For the DDI in Figure 9(b), one additional cycle begins in June



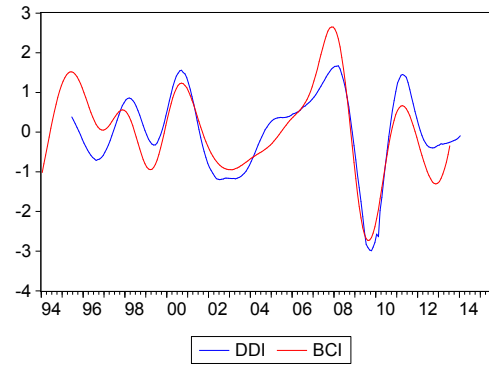
(a) ALI and BCI, HP-filtered



(b) DDI and BCI, HP-filtered



(c) ALI and BCI, RW-filtered



(d) DDI and BCI, RW-filtered

Figure 9: Comparisons of indicators (blue) and reference cycle (BCI, red)

of 2003 and remains to December 2005. This is a cycle longer than two years (longer than the pass-band limit setting). Hence the additional cycle is either a spurious cycle caused by the HP-filter, or the RW-filter may suffer from compression. Because no official turning point is defined during this period²⁶, the data suggest that the cycle is a spurious cycle and caused by the structure of the HP-filter.

Because the HP-filter is a moving average, and the ends lack observations, larger trend kinks will be allowed at the ends of the series, resulting in data at the ends of the series having an exaggerated impact on the trend. It's not possible to determine

²⁶The OECD registers all peaks and troughs in the OECD economies, following a methodology based on their recognized definition of a peak and a trough.

the magnitude of this end-point bias due to the high level of noise of the series. The RW-filtered series don't suffer from end-point bias, however the RW-filter filter is asymmetric and may therefore suffer from phase shifts. One way to discover phase shifts is to compare the timing of the series' turning points to the OECD's officially established turning points. This examination shows that all turning points in the RW-filtered series match the officially established ones and hence no phase shift seems to have been introduced by the RW-filter.

Taken together, the RW-filter does not seem to introduce any substantial bias to the indicators nor the BCI, whereas the HP-filter is more erratic and introduces one spurious cycle and leaves a large amount of noise in the filtered series. Therefore the study will hereafter only focus on the indicators filtered by the RW-filter.

5.2 Bias, Efficiency and Accuracy

The result of the standard evaluation measures are shown in Table 2. The evaluated period of ALI Sweden is 2001-2013 because it's not until June 2000 that the index contains all series and is a complete indicator. The DDI is complete from its start date in 1994 and is evaluated for the period 1994-2013.

	Theil's U	MAE	RMSE	Bias	Efficiency
<i>ALI Sweden</i>	0.22	0.32	0.45	-0.021	p-value: 0.10
<i>DDI</i>	0.27	0.46	0.56	0.004	p-value: 0.44

Table 2: Accuracy, Bias and Efficiency

Both ALI Sweden and DDI beats a naive forecast (Theil's U are less than one) and hence both indicators predict better than guessing would do. ALI Sweden has smaller MAE as well as RMSE than the DDI which suggests that ALI Sweden is slightly more accurate than the DDI. On the other hand, the DDI contains almost no bias at all whereas ALI Sweden tends to slightly underestimate the business cycle. Both indicators are efficient although ALI Sweden could possibly be more efficient with the inclusion of the variable RU , which weakly (on the 10% rejection level) significantly explains the forecasting error of ALI Sweden. In this particular case of the RU index, including it would however result in shorter lead time because RU is an indicator for the current state. The result of the efficiency should rather be interpreted as a possibility to improve efficiency with other information than already included in the indicator. The RU index cannot significantly explain the forecasting error of the DDI, which is in line with DDI being unbiased and based on a large pool of data.

5.3 Turning points evaluation

When evaluating forecasting tools, it's common to present an "expanding window" where a real time development of the indicator is shown. This isn't feasible here, since the ALI Sweden contains individually lagged series and therefore can't be "unlagged" and show real time data. Instead the the indicators' performance of predicting turning points will be presented in two tables. The evaluation starts from the year in which the indicator is complete, year 2000 for ALI Sweden 1994 for the DDI.

The indicator ALI Sweden predicts seven turning points although only six turning points are confirmed by the business cycle, see Table 3. In June 2003, the indicator predicted an upturn which didn't realize. For the correct predictions, the lead time varies between three months and twelve months.

	Turning point dates as predicted by ALI Sweden	Turning points dates in BCI	Lead (months)
Peak	2000M03	2000M06	3
Trough	2002M03	2003M03	12
Peak	2003M05	-	Extra
Peak	2007M03	2008M01	10
Trough	2009M06	2009M09	3
Peak	2011M02	2011M05	3
Trough	2012M07	2012M12	5

Table 3: Peaks and troughs, ALI Sweden and BCI

Also DDI predicts one additional turning point compared to the BCI, see Table 4. The turning point is between the same trough and peak as for ALI Sweden but peaks in February 2004 (nine months after ALI Sweden's extra peak). In total, the DDI predicts 10 turning points during the investigated period. The lead time varies between three and ten months.

The indicators' varying lead time may be considered weak performance, but changing lead time is rather common among indicators. For comparison, see the internationally recognized Composite Leading Indicator (CLI) performance in Appendix 7.2 in which CLI's lead time during the period between 1996 and 2009 varies between one month and 13 months and also indicates one extra trough and misses one peak. Considering that ALI Sweden and DDI predict all turning points during the investigated period, the result is considered to be successful.

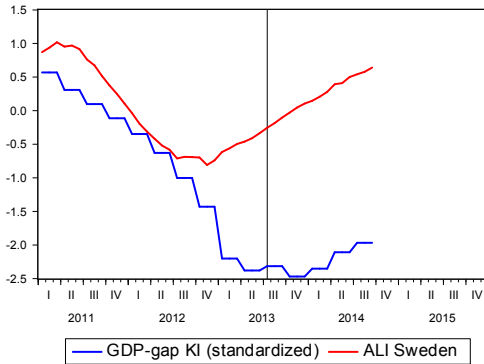
	Turning point dates as predicted by DDI	Turning points dates in BCI	Lead (months)
Trough	1996M03	1997M01	10
Peak	1997M09	1997M12	3
Trough	1998M11	1999M05	6
Peak	2000M03	2000M06	3
Trough	2002M04	2003M03	11
Peak	2004M02	-	Extra
Peak	2007M08	2008M01	5
Trough	2009M03	2009M09	6
Peak	2010M10	2011M05	7
Trough	2012M02	2012M12	10

Table 4: Peaks and troughs, DDI and BCI

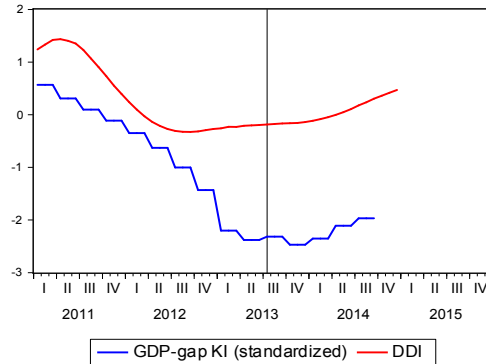
5.4 Real time evaluation

The methodology used in this paper is primarily an empirical statistical investigation to find series that constitute an indicator which explains the observed business cycle and hopefully also predicts the coming business cycle. To evaluate the performance of the same data used in the construction process is therefore not sufficient for an unbiased evaluation. One year (July 2013 to July 2014) of data is excluded from the construction process to use for out-of-sample forecasting unbiased evaluation. A second action to reduce the risk of unbiased evaluation is to compare the out-of-sample performance to a (standardized) GDP-gap other than the one developed in this study. The quarterly released GDP-gap by the Swedish NIER (*Konjunkturinstitutet (KI)*), hereafter called GDP-gap KI, is now used as the reference cycle.

Figure 10(a) shows ALI Sweden in red and GDP-gap KI in blue. The ALI is lagged by three months to co-move with the reference cycle. Figure 10(b) shows DDI in red and GDP-gap KI in blue. The DDI is lagged by seven months to co-move with the reference cycle. The vertical line in July 2013 represents where the out-of-sample begins for the indicators. The GDP-gap KI turns upward in late 2013. Both indicators start to signal this turn before their estimated average lead time (three months for ALI and seven months for DDI). The ALI indicator started to signaling the recovery already in 2012 which gives a lead of three quarters. The DDI started signaling the recovery, modestly but stably, in the beginning of 2012.



(a) ALI and NIER's GDP-gap



(b) DDI and NIER's GDP-gap

Figure 10: ALI Sweden and DDI compared to standardized GDP-gap from NIER Sweden (Konjunkturinstitutet (KI))

The data suggest that both indicators do not just explain the ex-post business cycle but also predict the out-of-sample business cycle well. One should however interpret this evaluation with caution due to the very limited time period investigated.

6 Discussion and Conclusions

6.1 Discussion on the construction of ALI Sweden

The objective of this study was to investigate whether the existing framework of the indicator ALI orig could be applied to the context of Sweden and successfully forecast the Swedish business cycle. This study has shown that the framework developed by de Bondt and Hahn (2010) can be used to construct a successful leading indicator for Sweden. ALI Sweden performs very well in predicting turning points. In the out-of-sample evaluation, ALI Sweden correctly predicted the turning point in late 2013 (also much earlier than three months) and predicts accurately according to low RMSE and MAE. ALI Sweden's general lead time of three months (varies up to twelve months) is however shorter than hoped (six months). The different lead time in this study and Bondt and Hahn's study, may be explained by the different access to long data series.

In ALI orig, most data go back all the way to 1970, whereas almost no such long series exist for Sweden's economy. In the case where long series for the Swedish

economy were available, the selection process was constrained by the Industrial Production Index series' (the BCI's) length, which, even after merging the series with a historic back-calculation series, only went back to 1980. The difference in data availability may have two explanations. Firstly, de Bondt and Hahn have had access to data not available to the public, which would explain the differences in series between ALI orig and the replicated ALI. Secondly they could use series from 16 (at the time) Euro area countries and other influential economies, whereas this study took series from only one country and other influential economies. The limited data availability lead to difficult trade-offs between using long series and using new series containing important information for today's economy, such as Consumer confidence and Economic sentiment (starts in 1993 and 1990 respectively), with the consequence of less certain lead time in the composite index.

In the construction process, a difference, neither derived from the series' length nor availability, is present due to the differences in economic areas to forecast. Because Germany has a large impact on the the Euro zone economy but the business cycle is an aggregate of the whole Euro Area, including more variables from Germany than for other countries in the Euro Area will make the indicator lead the aggregate Euro Area business cycle more than if the series represented the countries' business cycles. This "trick" is not possible in ALI Sweden because Sweden's business cycle has a much smaller lag with respect to Germany than the Euro Area aggregate of different business cycles.

This study introduced two additional elements in the construction of ALI Sweden: an alternative reference cycle (Service Production Index) and one more filtering method (HP-filtering) to separate the business cycle from the long run trend. For the reference cycle, Service Production Index was not found to be a better proxy of GDP than Industrial Production Index, even though Sweden has a large share of services in the economy. That can be due to services being labor intensive and therefore inflexible to changes. The HP-filter, in turn, was introduced to this study owing to its large recognition and would work as a comparison to the RW-filter. As it turned out, the HP-filtered series were too noisy for a meaningful analysis of the business cycle and were therefore not analyzed in the rest of this study. Thus, none of these alternatives in methodology lead to an improved result.

Because the criteria used in the selection process were not exhaustive and may introduce bias, a data driven indicator was created for comparison. The evaluation suggests that ALI Sweden suffers from a tendency to slightly underestimate the business cycle, whereas DDI has almost zero bias. Both indicators are efficient but the ALI indicator can possibly be more efficient according to the explanatory test variable being almost significant (p-value of 10%).

The conclusion is that the framework used to construct ALI orig can be used to construct a leading indicator which successfully predicts turning points accurately. It has a somewhat limited lead time compared to ALI orig, but should be possible to extend with an expanded pool of available data.

6.2 Policy recommendations

The indicator ALI is a constant parameters indicator, meaning it's static in its composition; the series included in the index are constant (unless the indicator is not derived again). This makes an ALI type indicator insensitive to changes in economic areas previously not considered important enough to be included in the indicator. This makes the indicator less robust. An indicator derived in a PCA setting on the other hand extracts a new PC from the pool of data every time it's updated with new data. Thus, assuming there is enough variation in the pool of data, the DDI will be more updated of emerging changes. Also, it's easy to include more data to the data pool if a specific country is very influential at the moment. This flexible construction of the PC makes the DDI a more updated indicator for changes in the economy.

The number of series included in the indicator matters. ALI consists of nine economic series which places high demands on these series to be correctly selected, as discussed in the previous section. The DDI is derived from 36 economic series, which can also be extended with no disadvantages, which makes the selection process minimal and removes possible bias from the selection process, which was indeed the reason to create a DDI for this study.

The large drawback of using the DDI is the lack of insight in the extraction process – some refer to it as a "black box". An ALI indicator on the other hand is transparent and its performance can easily be checked and understood by the user. The open procedure also gives the possibility to look at the individual series in order to understand which series are driving a specific performance of the ALI indicator. In this study, the DDI has zero bias whereas the ALI Sweden indicator slightly underestimates the business cycle, but is slightly more accurate than the data driven indicator. Both indicators are efficient, although ALI Sweden can possibly be improved. Hence, the outcome of this comparison is a recommendation to use both indicators. The DDI for its flexibility and more sophisticated structure, and ALI for its validity due to transparency.

7 Appendix

7.1 Filtering Methods Mathematically

The HP-filter The trend is formulated by the sum of squares of the full series second difference, which is the solution to the following minimization problem

$$\min_{\tau} = \left(\sum_{t=1}^T (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \right) \quad (7)$$

The full series is denoted as Y and the trend component as τ . The trend component and the cyclical component are both weighted averages of the Y . Together they create the cyclical component $(Y - \tau)$ which is simply the deviation between the full series and the trend. The first term in equation 7 minimizes the cyclical component and the second determines how much the trend component is allowed to vary, set by the the smoothing parameter λ .

The Baxter and King filter The Baxter and King moving average:

$$\nu = \sum_{n=-K}^K h_n u_{j-n}, \quad (8)$$

where ν is the new time series, u is the original time series and h is the weight.

The optimal K is derived by truncating at $\nu = 0$, that is, $H(0) = 0$ for bandpass and highpass filter and $H(0) = 1$ for lowpass filter. The derivative with respect to the weights gives the following solution:

$$h_j^{BK} = h_j^{ideal} + \frac{H(0) - \Delta t \sum_{n=-K}^K h_n^{ideal}}{(2K + 1)\Delta t}, \quad (9)$$

which is the ideal band-pass filter weight plus a constant fraction introduced by the truncation K (Iacobucci and Noullez, 2005). The choice of leads and lags, hereafter K , is a trade off between accuracy and observations left for analysis. The more leads and lags, the closer the filter will be to the ideal band-pass filter. When K approaches infinity, there would be no leakage or compression which can be seen in equation 9; the error term shrinks when K grows. But on the other hand, increasing K will leave fewer data points left for analysis which would weaken the filter. Baxter and King suggest to set K to three years and $K12$ for both quarterly and annual data, regardless of the number of observations in the sample (Baxter and King; 1999).

7.2 CLI

Table 5 shows a similar table as shown for the ALI Sweden indicator but for the internationally recognized Composite Leading Indicator (CLI) and Industrial production index as reference cycle (BCI):

	Turning points as predicted by CLI	Turning points BCI	Lead
Peak		1992M09	
Through		1994M09	
Peak	1997M06	1997M11	5
Through	1998M09	1999M03	6
Peak	1999M12	2000M01	1
Through		2001M12	Missed
Through	2002M07		Extra
Peak	2004M10	2005M10	12
Through	2005M07	2006M08	13
Peak	2007M04	2008M02	10
Through	2008M12	2009M05	5

Table 5: CLI peaks and troughs. Source: OECD

References

- Agresti, A.M. and B. Mojon *Some Stylised Facts on the Euro Area Business Cycle* Cambridge University Press, Part 1, Chapter 1, pp. 15-35, 2003.
- Altissimo, F., A. Bassanetti, R. Cristadoro, M. Forni, M. Lippi, M. Hallin, L. Reichlin, G. Veronese; *Eurocoin: A Real-time Coincident Indicator of the Euro Area Business Cycle* Centre for Economic Policy Research Discussion Paper No. 3108, 2001.
- Altissimo, F., R. Cristadoro, M. Forni, M. Lippi and G. Veronese *New Eurocoin: Tracking Economic Growth in Real Time* Centre for Economic Policy Research Discussion Paper No. 3108. 2001 Bank of Italy Discussion Paper No. 631, July, 2007.
- Baxter, Marianne and King, Robert; *Measuring business cycles: Approximate Band-Pass Filters for Economic Time Series*. University of Virginia, 1999.
- Bell, W., *Signal Extraction for Nonstationary Series*. The Annals of Statistics, 12, 646-664. 1984.
- Beveridge, S. and Nelson, C; *A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the "business cycle"*. Journal of Monetary Econotnics, vol. 7, pp. 151-74. 1981.
- Blanchard, Olivier Jean and Quah, Danny; *The Dynamic effects of aggregate demand and supply*. American Economic Review, 79: 655-673 1989.
- Burns, Arthur F and Mitchell, Wesley C *Measuring business cycles*, Published by NBER in NBER Book Series Studies in Business Cycles, 1946.
- Christiano, Lawrence J. and Fitzgerald, Terry J *The Band Pass Filter*, 1946. International Economic Review, Vol.44, No.2, pp.435-465. 2003.
- Cogley, Timothy and James Nason; *Effects of the Hodrick-Prescott filter on trend and difference stationary time series. Implications for business cycle research*. Journal of Economic Dynamic and Control, 19, 253 - 278, 1995.
- De Bondt, Gabe and Hahn, Elke; *Predicting recessions and recoveries in real time the euro Area-wide Leading Indicator (ALI)*. Working paper No 1246, European Central Bank, 2010.

- Denis, C., K. M. Morrow, and W. Roger; *Production function approach to calculating potential growth and output gaps - estimates for the EU member states and the US*. European Commission Economic Papers No. 176, 2002
- Dolado, J.J., Sebastin, M., Valls, J. *Cyclical Patterns of the Spanish Economy*. Investigaciones Econmicas, XVII, 445-473. 1993
- Elliott, Graham and Timmermann, Allan; *Handbook of Economic Forecasting* Volume 2, Part 2, chapter 4.1, 2013.
- Estrella, Arturo; *Extracting Business Cycle Fluctuations: What Do Time Series Filters Really Do?*. Federal Reserve Bank of New York Staff Reports no. 289 June, 2007.
- Fair, Ray C; *Handbook of Econometrics, Vol. III*. ed. Z. Griliches and M.D. Intriligator, Elsevier Science Publishers BV, ch. 33. 1986.
- Fernandez-Villaverde, Jesus, Juan F. Rubio-Ramrez, and Manuel S. Santos *Convergence Properties of the Likelihood of Computed Dynamic Models*. Econometrica 74, 1 2006: 93-119, 2006.
- Giles E. David *Constructing confidence bands for the HodrickPrescott filter*. Applied Economics Letter, 20 Aug 2012.
- Granger, Clive W.J; *The typical spectral shape of an economic variable*. Econometrica 34: 150-161, 1966.
- Hamilton, James D *A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle*. Econometrica 57, 357-384, 1989.
- Harman, Harry; *Modern factor analysis*. University of Chicago press Chicago, 1976.
- Hodrick, Robert. J. and Edward. C, Prescott; *Postwar U.S. business cycles: an empirical investigation*. Journal of Money Credit and Banking 29, 1-16. 1997.
- Iacobucci, Alessandra and Noullez, Alain; *A Frequency Selective Filter for Short-Length Time Series*. Computational Economics 25:1-2, 75-102, 2005.
- Johnson, Richard.A., and Dean.W. Wichern; *Applied Multivariate Statistical Analysis* Third Edition, Prentice Hall, Englewood Cliffs, New Jersey, 642 p, 1992.

- Kaiser, Regina; Maravall, Agustin *Estimation of the business cycle: A modified Hodrick-Prescott filter*. Spanish Economic Review., Vol. 1 Issue 2, p175. 32p. 9 Charts, 24 Graphs. 1999.
- Koopman, Tjalling C; *Measurement without theory*. Review of Economics and Statistics 29, 161-179, 1947.
- Marcellino, Massimiliano; *Leading Indicators*. In: Elliott, G, CWJ. Granger and A. Timmerman (ed), Handbook of economic forecasting Elsevier, vol 1, ch 16 pp 879-960.
- Meese, Richard and Rogoff, Kenneth *Empirical exchange rate models of the seventies*. Journal of International Economics, 1983.
- Nelson, Charles R. *trend/cycle decomposition* From The New Palgrave Dictionary of Economics, Second Edition, 2008.
- Nyman, Kristina; *An indicator of resource utilization*. Working paper no.4. Sveriges Riksbank, 2010.
- Otsu, Takeshi; *Time-invariant linear filters and Real GDP: A case of Japan* Seijo University Economic Papers 174, 29-47, The Economic Institute of Seijo University (Japan), 2007.
- Pedersen, Torben Mark; *The Hodrick-Prescott Filter, the Slutsky Effect, and the Distortionary Effect of Filters*. Journal of Economic Dynamics and Control, Vol. 25, pages 1081-1101, 2001.
- Pollack, D.S.G; *Trend estimation and de-trending via rational square-wave filters*. Journal of Econometrics. Vol. 99 Issue 2, p317. 18p. 10 Graphs, 2000.
- Ravn, Morten and Uhlig, Harald; *On adjusting the HodrickPrescott filter for the frequency of observations* The Review of Economics and Statistics 84 (2): 371375, 2002.
- Richard A and Wichern, Dean W Applied multivariate Statistical Analysis ch. 8. Pearson, 1992.
- Slutsky Eugen; *The summation of random causes as the source of cyclical processes*. Applied multivariate Statistical Analysis ch. 8. Pearson Econometrica, 5: 105 46, 1937.

Whittaker, E. T. *On a New Method of Graduation*. Proc. Edinburgh Math. Soc., Vol. 41, 63-75, 1923.

Whittle, Peter. *Prediction and Regulation*. English Universities Press, 1963.

Wiener, Norbert *Extrapolation, Interpolation, and Smoothing of Stationary Time Series*. New York: Wiley, 1949.

Woitek, Ulrich *A Note on the Baxter-King Filter*. Working Papers 9813, Business School - Economics, University of Glasgow, 1998.

Data sources:

Eurostat (<http://epp.eurostat.ec.europa.eu> and through Sweden's Ministry of Finance's access to the database)

International Monetary Fund's database (through Sweden's Ministry of Finance's access to the database)

The National [Sweden's] Institute of Economic Research *Konjunkturinstitutet* (<http://www.konj.se>)

Statistics Sweden *Statistiska Centralbyran* (<http://www.scb.se>)

Sweden's central bank *Sveriges Riksbank* (<http://www.riksbank.se>)