DEUTSCHE BUNDESBANK EUROSYSTEM

Technical Paper

An unconventional weekly economic activity index for Germany

02/2020

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Non-technical summary

The WAI is a weekly index designed to measure real economic activity in Germany in a timely manner. The index is calculated as a common component from a number of high-frequency indicators that are quickly available and cover various economic sectors. In addition, monthly industrial output and the most recently available quarterly gross domestic product (GDP) feed into the index. The WAI and the GDP growth estimate derived from it supply timely information on developments in economic activity in Germany.

The high-frequency indicators the WAI is based on (in addition to monthly industrial production and quarterly GDP) are recorded on a weekly basis and are quickly available. The indicators “electricity” and “toll” (road charge) capture the production sector and trade; the “flights” indicator creates a point of reference for global activity; “G-unemployment”, “G-short-time work” and “G-state support” (derived from Google search queries) relate to the labour market and the extent to which state support measures are discussed; “pedestrian frequency” captures one part of consumer behaviour; “air pollution” serves as a metric for the mobility sector; and “consumer confidence” reflects a part of consumer sentiment.

When constructing the index, 13-week growth rates of 13-week averages for the high-frequency indicators are computed. The WAI is then calculated as the common factor within the mixed-frequency dataset by means of a so-called principal component analysis. The WAI fluctuates around its long-term mean, which is zero by construction. So, positive values indicate above-average growth in real economic activity, while negative values signal a below-average increase or a decline in economic output. Its values can be interpreted as rolling 13-week growth rates. At the end of a given quarter, the values of the WAI can be viewed (in approximate terms) as quarter-on-quarter rates of change.

Historically, the WAI tracks quarterly GDP quite well and exhibits a relatively high correlation with it (measured using end-of-quarter values). As of mid-March 2020, it records a sharp decline and hence implies a significant slowdown in economic activity. The timing of this massive decline coincides with the strict measures taken to contain the coronavirus pandemic. With the start of the successive easing of these measures in May, however, the WAI recovers sharply from June onwards, pointing to a strong recovery in the following months.

Nichttechnische Zusammenfassung

Der WAI ist ein wöchentlicher Index, der die realwirtschaftliche Aktivität in Deutschland möglichst zeitnah messen soll. Der Index wird als gemeinsame Komponente aus mehreren hochfrequenten, schnell verfügbaren Indikatoren berechnet, die verschiedene Wirtschaftsbereiche abdecken. Zusätzlich fließen die monatliche Industrieproduktion sowie das letztverfügbare, vierteljährliche Bruttoinlandsprodukt (BIP) in den Index ein. Der WAI und die daraus abgeleitete Schätzung für das BIP-Wachstum liefern zeitnahe Informationen darüber, wie sich die Wirtschaftstätigkeit in Deutschland entwickelt.

Neben der monatlichen Industrieproduktion und dem vierteljährlichen BIP setzt sich der WAI aus hochfrequenten, wöchentlich erfassten, schnell verfügbaren Indikatoren zusammen. So erfassen die hochfrequenten Indikatoren Strom und Maut den Bereich Produktion bzw. Handel, während der Indikator Flüge einen Bezug zur globalen Aktivität herstellt. Aus Google-Suchanfragen werden die Variablen G-Arbeitslosigkeit, G-Kurzarbeit und G-Staatshilfe gewonnen. Die ersten beiden beziehen sich auf den Arbeitsmarkt, G-Staatshilfe erfasst das Ausmaß, in dem die staatlichen Hilfsmaßnahmen diskutiert werden. Der Indikator Passantenaufkommen bildet einen Teil des Konsumverhaltens ab, die Größe Luftverschmutzung dient als Kennzahl für den Bereich Mobilität und das Konsumentenvertrauen misst einen Teil der Verbraucherstimmung.

Bei der Erstellung des Index werden von den hochfrequenten Indikatoren 13-Wochen-Wachstumsraten von ihren 13-Wochen-Durchschnitten gebildet. Der WAI wird anschließend über eine Hauptkomponentenanalyse als gemeinsamer Faktor des gemischtfrequenten Datensatzes berechnet. Der WAI schwankt um seinen langfristigen Mittelwert, der konstruktionsbedingt bei null liegt. Folglich weisen positive Werte auf eine überdurchschnittlich stark steigende realwirtschaftliche Aktivität hin, während negative Werte eine unterdurchschnittliche Steigerung oder ein Sinken der Wirtschaftsleistung andeuten. Seine Werte können demnach als rollierende 13-Wochen-Wachstumsraten interpretiert werden. Am Ende eines Quartals können die WAI-Werte näherungsweise als Veränderungsrate gegenüber dem vergangenen Quartal angesehen werden.

In der Vergangenheit konnte der WAI das vierteljährliche BIP-Wachstum ausgesprochen gut nachbilden, was sich in einer recht hohen Korrelation (berechnet auf Basis seiner Werte an Quartalsenden) widerspiegelt. Ab Mitte März 2020 deutete er auf einen scharfen Rückgang und damit eine signifikante Verlangsamung der wirtschaftlichen Aktivität hin. Zu diesem Zeitpunkt wurden strenge Maßnahmen zur Eindämmung der Coronavirus-Pandemie eingeführt. Mit der sukzessiven Lockerung dieser Maßnahmen erholte sich der WAI stark.

An unconventional weekly economic activity index for Germany*

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Abstract

We develop an unconventional activity index for the German economy at weekly frequency in order to monitor economic developments at the current end in real time. The index contains nine high-frequency, rather unconventional weekly indicators. These are augmented by monthly industrial production and quarterly gross domestic product. The weekly activity index is then calculated as the common factor of the mixed-frequency dataset. It turns out that the index exhibits a high correlation with quarterly GDP growth and is thus able to serve as a reliable weekly coincident indicator for economic activity in Germany.

Keywords: business cycle, economic indicator, factor analysis

* We thank our colleagues in the Macroeconomic Analysis and Projections Division as well as members of the Bundesbank Group on Forecasting for their helpful discussions. Technical papers represent the authors' personal opinions and do not necessarily reflect the views of the Deutsche Bundesbank or the Eurosystem.

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1 Introduction

The coronavirus pandemic and the measures taken to contain it caused a severe recession for the German economy. The economic costs of the pandemic and the related counter-measures are, however, unclear. Nearly every forecast which is currently published by various institutions emphasises the high degree of uncertainty surrounding their estimates. This is, amongst other things, due to the lack of experience with such an underlying shock. A pandemic of such a scale causing such drastic public health measures has not occurred for a century. The uncertainty also arises because of the unprecedented speed with which the economy went into recession. Especially in such a situation, precise and up-to-date estimates of the economic consequences are of utmost importance, not least, since far-reaching economic and public health decisions are made on their basis.

Short-term economic analyses and forecasts, as they are regularly conducted in, e.g., central banks, aim at providing a quantitative measure of macroeconomic developments as well as their driving forces. At the current juncture, there are, however, two problems: first, conventional forecast models are based on the dynamic relations between the underlying indicators in the past. In view of the unprecedented nature of the current crisis, these relationships have likely changed by now. Second, most of the underlying indicators – both "hard" indicators such as industrial production or retail sales as well as "soft", survey-based sentiment indicators – are available with a delay. Therefore, conventional forecast models are probably not correctly specified, implying that they may not yield reliable forecasts in such economic circumstances.

We introduce a new weekly activity index (WAI) for the Germany economy inspired by Lewis, Mertens and Stock (2020a, b). Apart from industrial production and gross domestic product, the index is composed of timely indicators available at high frequency. These rather unconventional – in the sense of classic short-term macroeconomic forecasting – indicators are chosen so as to contain relevant information from different sectors of the economy. The index is then constructed as the common factor of the dataset that consists of indicators at weekly, monthly and quarterly frequencies. This way, the WAI delivers a timely, data-driven measure of the economic consequences of the coronavirus crisis.

The remainder of this paper is set out as follows. The next section provides an overview of the data used in this study. Section 3 introduces the econometric methodology. Section 4 describes the weekly activity index and discusses our empirical findings. Section 5 concludes.

2 Data

We use weekly, monthly and quarterly indicators for the construction of the index. Given the unconventional nature of the available high-frequency indicators, we demand sufficient explanatory power in relation to economic activity, aim at covering as many economic sectors as possible and include two lower-frequency macroeconomic indicators in our dataset. Table 1 provides an overview of the indicators used in the construction of the WAI. Note that daily indicators enter the calculations as weekly averages.

Table 1: Indicators used in the WAI

Indicator	Description	Frequency	Release pattern
Electricity	Realised electricity consumption (excluding industrial grids and producers' own use)	daily	daily $(t-1)$
Toll	Daily truck toll mileage index	daily	Thursdays $(t-9)$*
Pedestrian frequency	Pedestrian frequency in selected shopping districts in large German cities	daily	daily $(t-1)$
Consumer confidence	Current personal financial and buying conditions	daily	daily $(t-1)$
Air pollution	Nitrogen dioxide concentration in the air (average of all available cities and towns in Germany)	daily	Mondays $(t-3)$
Flights	Worldwide number of passenger and cargo flights	daily	daily $(t-1)$
G-unemployment	Relative search frequency for Google search term "unemployment"	weekly	Mondays $(t-2)$
G-short-time work	Relative search frequency for Google search term "short-time work"	weekly	Mondays $(t-2)$
G-state support	Relative search frequency for Google search term "state support"	weekly	Mondays $(t-2)$
IP	Industrial production	monthly	monthly $(ca.\,t-35)$
GDP	Gross domestic product	quarterly	quarterly $(ca.\,t-30)$**

Notes: This table presents the indicators used in the construction of the WAI. The first column displays the indicator, while the second provides a brief description. The column "Frequency" gives the frequency at which the data are downloaded. The final column shows the release pattern of the selected indicators. * As of 19 October 2020, the Federal Office for Goods Transport, the data provider for the toll (daily truck toll mileage index) indicator, stopped delivering the data on a daily basis. Instead, as of 22 October, they are provided on a weekly basis on Thursdays, leading to a change in publication lag from 5 to 9 days. ** As of the end of July 2020, the Federal Statistical Office changed the release date of the flash

estimate for GDP from approx. 45 to approx. 30 days after the end of the quarter.

The high-frequency indicators electricity[1] and toll[2] record the production sector, while the latter also captures the trade sector. Pedestrian frequency[3] and consumer sentiment[4] measure a part of consumer behaviour. The variable air pollution[5] provides a metric for mobility. The number of worldwide flights[6] accounts for global activity. Relative Google search frequencies for "unemployment" and "short-time work" reflect the dynamics of the domestic labour market, while the search frequency for "state support" captures measures taken by the government to support the economy.[7] In addition to these high-frequency indicators, we include monthly industrial production and quarterly gross domestic product[8] in our dataset. We use seasonally and calendar-adjusted series for indicators exhibiting marked seasonal and/or calendar patterns.

3 Econometric methodology

The WAI is calculated as the common factor of various indicators that are available at different frequencies and have distinct release patterns. Therefore, the adopted methodology has to be able to deal with data at mixed frequencies as well as with missing observations. We achieve this in two steps: first, in order to address the former we transform the indicators in a way such that they represent comparable growth rates.[9] Subsequently, we utilise a method which is able to extract factors from a dataset with missing observations.

The data transformation in the first step is oriented towards quarterly growth rates, which represent the rate of change of the average value of a quarter compared with that of the previous quarter, such as the quarterly GDP growth rate. Specifically, we take (the

[1] Realised electricity consumption excluding industrial grids and producers' own use; source of unadjusted figures: Federal Network Agency (Bundesnetzagentur).
[2] Daily truck toll mileage index; source of unadjusted figures: Federal Office for Goods Transport (Bundesamt für Güterverkehr) and Federal Statistical Office.
[3] Average number of pedestrians on selected shopping streets in large German cities weighted by the 2018 population; source of unadjusted figures: Hystreet.
[4] Index of current conditions (ICC) based on current personal financial and buying conditions; source: Morning Consult Economic Intelligence (MCEI).
[5] Average nitrogen dioxide concentration in all available cities and towns in Germany; source of unadjusted values: European Environmental Agency.
[6] Worldwide number of passenger and cargo flights; source of unadjusted data: Flightradar24.
[7] Relative search frequencies for Google search terms "unemployment", "short-time work" and "state support"; source of unadjusted figures: Google Trends.
[8] The data for industrial production and GDP are obtained from the time series database of the Deutsche Bundesbank.
[9] In mixed-frequency econometric models, such as the dynamic factor model developed by Aruoba, Diebold and Scotti (2009), indicators at various frequencies can be transformed into a desired frequency by means of a temporal (dis)aggregation as proposed by Mariano and Murasawa (2003) or similar approaches. The WAI, however, is not based on a comparable econometric framework. Thus, we follow an alternative approach to dealing with the mixed-frequency dataset.

equivalent of) 13-week growth rates of 13-week moving averages for the weekly indicators[10] and three-month growth rates of three-month moving averages for monthly indicators. This can be written as

$$\Delta^q y_t^w = \ln\left(\frac{1}{13}\sum_{i=0}^{12} y_{t-i}^w \Big/ \frac{1}{13}\sum_{i=13}^{25} y_{t-j}^w\right)$$

and

$$\Delta^q y_t^m = \ln\left(\frac{1}{3}\sum_{i=0}^{2} y_{t-i}^m \Big/ \frac{1}{3}\sum_{i=3}^{5} y_{t-j}^m\right).$$

In this way, we generate *quartalised* growth rates for weekly and monthly indicators, denoted as $\Delta^q y_t^w$ and $\Delta^q y_t^m$. They represent the logarithmic rate of change over the past 13-week average compared with the average of the preceding 13-week period. Therefore, at the end of a given quarter, such rolling quartalised growth rates may be interpreted approximately as quarterly growth rates.

In the second step, we calculate our weekly activity index as the common factor of the transformed dataset. After the data transformation, the weekly, monthly and quarterly indicators are represented as quartalised growth rates and thus have a comparable unit. This allows us to interpret the initially mixed-frequency dataset as a dataset with missing observations, in which quartalised growth rates for weekly, monthly and quarterly indicators are observed every week, every $4^{th}/\,5^{th}$ week, and every $13^{th}\,/\,14^{th}$ week.

The conventional principal component analysis (PCA) requires a balanced dataset. Therefore, the factor extraction method should be adapted to our dataset that contains missing observations. Against this background, we extract our weekly index by means of a PCA using the expectation maximisation (EM) algorithm.[11] In brief, the EM algorithm is an iterative method which estimates factors and fills missing observations until factor estimates do not change. Denoting the dataset in the i^{th} iteration as X^i, the EM algorithm may be summarised as follows:

Initialisation

(1) Missing observations are replaced by their unconditional means obtained from non-missing values of respective indicators. Let us denote this dataset as X^0.

[10] We approximate a quarter with 13 weeks. To be precise, each year consists of 52.14 weeks. With four quarters per year, this amounts to 13.035 weeks per quarter.

[11] The EM algorithm was initially developed by Dempster, Laird and Rubin (1977) and used for factor analysis in macroeconomic forecasting by Stock and Watson (2002), and more recently by McCracken and Ng (2016), amongst others.

(2) Demean and standardise X^0.
(3) Run a PCA to estimate the factor $\hat{F}^0$ and the vector of factor loadings $\hat{\lambda}^0$ from demeaned and standardised X^0.

Iterations $i = 1, \dots, m$

(4) Update only the initially missing observations in X^i with their estimated values (i.e., by calculating $\hat{\lambda}^{i-1}\hat{F}^{i-1}$ and rescale them to the initial magnitude by multiplying the series by their standard deviation and adding their unconditional means).
(5) Demean and standardise the entire X^i.
(6) Run a PCA to estimate $\hat{F}^i$ and $\hat{\lambda}^i$ from demeaned and standardised X^i.
(7) Repeat steps (4) – (6) up until iteration m, in which the change of the factor estimate falls below a certain threshold.

Finally, the EM algorithm provides us not only with the weekly activity index, but also estimates for the missing observations in the dataset. Therefore, helpful by-products of the EM algorithm are the factor-based estimates of the quartalised growth rates for industrial production and GDP at weekly frequency.

4 Weekly economic activity index

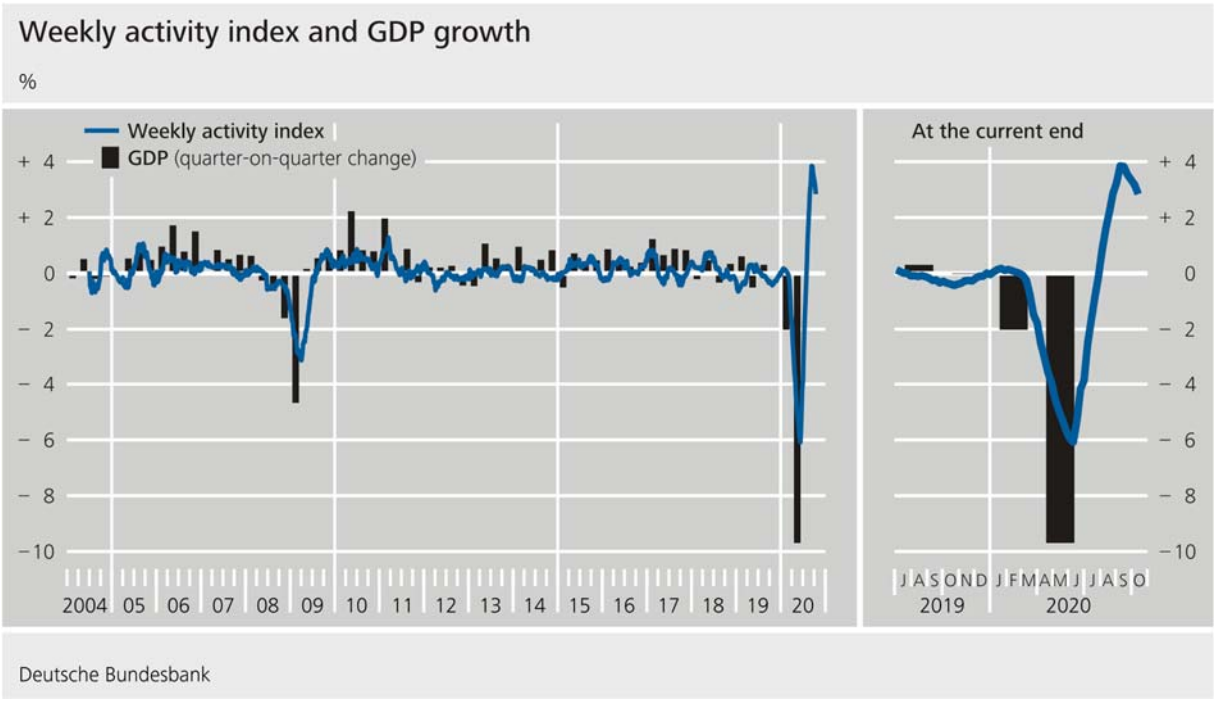
This section introduces the WAI and focuses on its current developments from mid-March onwards, when the measures taken to fight the coronavirus pandemic hit the German economy. In its baseline specification, it consists of 11 indicators in quartalised growth rates on a weekly basis and spans from July 2004 to October 2020.[12] Figure 1 plots the WAI as well as the quarterly GDP growth rate for the entire sample period in the left panel, and takes a closer look at 2020 in the right panel.

Figure 1 reveals that the WAI is able to track quarterly GDP growth in Germany remarkably well. Thereby, the index – measured by end-of-quarter values – exhibits a relatively high correlation (around 0.9) with the GDP growth rate over the entire sample period. The WAI is centred around zero by construction. Accordingly, positive values point to an above-average growth rate for real economic activity, whereas negative values hint at below-average or negative rates of change in real economic output. Moreover, the data

[12] Note that the first version of the WAI was introduced in Deutsche Bundesbank (2020). The "cash" indicator (withdrawals in euro) that was still part of this version has since been replaced by "pedestrian frequency". Moreover, two indicators were added during the update on 8 June: "consumer confidence" and "G-state support". Furthermore, the WAI has since been based on rolling 13-week growth rates instead of 12-week growth rates. Note that these three modifications lead to a marked downward revision of the index at the time. Currently, the WAI is updated every Monday and appears on the website of the Deutsche Bundesbank under https://www.bundesbank.de/en/statistics/economic-activity-and-prices/weekly-activity-index/weekly-activity-index-for-the-german-economy-833976

transformation of its underlying indicators enables us to interpret its values as rolling quartalised growth rates of weekly economic activity. That is to say, a WAI value of 3 in a given week suggests that the growth of economic activity over the past 13-week period compared to that of the preceding 13 weeks was 3 percentage points above its long-term average. Finally, its end-of-quarter values can thus be considered as quarterly growth rates of real economic activity as measured by the WAI.

Figure 1: Weekly activity index and GDP growth



Notes: This graph plots the weekly activity index (solid blue line) and quarterly GDP growth rates (black bars) in Germany over the sample period July 2004 to October 2020. The latest update of the WAI dates from 19 October 2020.

Focusing on recent developments, the WAI records a sharp decline as of mid-March and hence implies a significant slowdown in economic activity. The timing of this massive decline coincides with the strict measures taken to contain the coronavirus pandemic. With the start of the successive easing of these measures in May, however, the WAI recovers sharply from June onwards, pointing to a strong recovery in the following months. Especially in such economic circumstances, precise and up-to-date estimates of the state of the economy are of utmost importance. For instance, as of 12 May 2020 (the very first time we computed the WAI) and 28 June 2020, the WAI pointed to WAI-implied GDP growth rates of -1.9% and -5.2% for the first and second quarters of 2020, respectively. According to the Federal Statistical Office's flash estimates of 15 May 2020 and 30 July 2020, real GDP dropped by 2.2% and 10.1%, respectively. Against this background, the WAI provides a timely assessment of current economic activity and is thus able to serve as a reliable coincident indicator to track weekly

economic activity in Germany.[13]

5 Concluding remarks

We propose a simple approach to generating an activity index for the German economy at weekly frequency. To this end, we use high-frequency, rather unconventional indicators as well as monthly industrial production and quarterly GDP. In the construction of the index, we follow a distinct approach to dealing with indicators at mixed frequencies and utilise the EM algorithm to extract the weekly activity index from a dataset with missing observations.

The proposed index is able to track economic activity in Germany quite well. Thus, it is able to provide a timely assessment of the current economic developments on a weekly basis. Particularly in a rapidly changing (economic) environment, characterised by a large degree of uncertainty, the WAI is a valuable complement to classic forecast models. It also serves as a cross-check for alternative measures of the recent economic downfall as well as of the subsequent strong recovery, which are often partly based on ad-hoc assumptions or judgement.

Despite its high correlation with the quarterly GDP growth rates in Germany and the estimates of current GDP as well of industrial production that it generates as a by-product, the index must be considered with caution. The WAI is not based on an econometric model that is able to deal with data at mixed frequencies. By contrast, it follows a distinct method of dealing with the mixed-frequency dataset and uses a factor extraction algorithm on a dataset with missing observations. Therefore, its values cannot be directly compared with short-term predictions for GDP growth obtained from established forecast models. Extending the WAI into such a model, however, is left for further research.

[13] We also check the stability of our index in various ways. In doing so, we modify the dataset underlying the baseline specification by adding/removing high-frequency indicators and comparing the resulting factor estimations. Overall, the total variance as well as the proportion of the variance in the underlying indicators explained by the WAI appear to remain relatively stable across modified WAI specifications.

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