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Output gaps and cyclical indicators: Finnish evidence

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Abstract

The output gap is a commonly used tool to assess the state of the business cycle, and as such, a key input for policy makers. In this article, we employ principal components analysis (PCA) to derive an estimate of the output gap in Finland that summarizes the information of widely used cyclical indicators. This methodology produces an output gap that is similar to the ones obtained from the main methods used at the Bank of Finland and the European Commission, but requiring considerably less modelling effort. The method is also flexible and can readily be adopted to internalize additional information that captures special circumstances, such as the current pandemic. In this spirit, we extend our information set to include a service turnover indicator, and find that it clearly improves the method's ability to capture the exceptional downturn in 2020.

Keywords: cyclical indicators, output gap, potential output, principal component analysis, service turnover, COVID-19

JEL codes: E32, C38

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1. Introduction

The output gap measures transitory fluctuations of output around its potential, and is a commonly used tool to assess the state of the business cycle. Hence, reliable estimates of it are essential information for economic analysis and policy making. But such estimates typically incolve a large degree of uncertainty as they in turn rely on estimates of potential output which in itself is unobservable. Indeed, considerable effort has been spent on developing more precise output gap estimates (see, e.g. Álvarez et al. 2018). One important tradeoff in this regard is the tension between keeping a parsimonious information structure and capturing all relevant aspects of the economy as it evolves. This tension can become particularly acute when unusual circumstances unfold, such as the recent pandemic. This puts a premium on methods that can effortlessly be adopted to accommodate new information as needed.

In this article, we present an estimate of the Finnish output gap based on principal components analysis (PCA). Our methodology builds on Roeger et al. (2019), who extract a common cyclical component from several cyclical indicators for four euro area countries (Germany, Italy, Spain and Portugal). They assess the empirical performance of widely used business cycle indicators and find that inflation and external balance measures give ambiguous cyclical signals. Overall, the empirical findings of Roeger et al. (2019) provide some verification of currently used methods, as they indicate that the PCA output gaps are highly correlated with the output gap estimates of the EU's commonly agreed methodology (CAM, Havik et al. 2014) in these four countries. However, the benefit of the PCA methodology over the CAM is that it permits a flexible incorporation of different cyclical indicators in the output gap analysis.

As a baseline, we use the same seven cyclical indicators as in Roeger et al. (2019). This allows us to study how well their method can be adapted to Finnish data. We are also interested in comparing the findings with those of the unobserved components model (UCM) currently used at the Bank of Finland (Sariola 2019). However, the COVID-19 pandemic has had a particularly strong effect on service industries due to restrictive measures and social distancing. Indeed as argued by Roeger et al. (2019), the current debate on output gaps does not pay sufficient attention to the empirical performance of individual business cycle indicators. Hence, in order to take the specifics of the pandemic into account, we extend the baseline set of indicators to include an index of turnover of service industries[1].

Our empirical findings indicate that the economic cycle had cooled down even before the COVID-19 pandemic and the output gap turned slightly negative at the end of 2019. The findings also suggest that the decline in the service industry turnover had a substantial effect on the output gap in the spring of 2020, due to the restrictive measures and social distancing

[1] The index of turnover of service industries describes development in the turnover of service branch enterprises (excluding trade). Source: Statistics Finland.

caused by the COVID-19 pandemic. This indicator also has an effect during other times as well, and is therefore a useful addition to the set of variables. Furthermore, the inclusion of a service sector indicator is justifiable in order to get full coverage of the economy, as the baseline set of variables already includes a specific indicator for manufacturing (capacity utilization).

Finally, we find that the estimates of the PCA output gap are in line with those given by the main tool used to evaluate the output gap at the Bank of Finland (Sariola 2019) during normal times.[2] The PCA output gap estimates are also in line with the estimates provided by the European Commission (European Commission forecast spring 2021). However, flexible extensions of the model can be beneficial during unusual times – the Covid-19 pandemic in our case. For instance, our extended version of the output gap can account for an additional 1.1 percentage point reduction in the output gap in 2020 during the peak of the pandemic compared to the Bank of Finland UCM model.

The rest of the article is organized as follows. The next section provides an overview of cyclical indicators used in output gap analysis. In Section 3, the methodology is presented, and in Section 4 we present the empirical findings. Section 5 concludes.

2. Cyclical indicators

In this section, we discuss frequently used cyclical indicators. We have selected the variables based on Roeger et al. (2019), but complement the set with a services sector indicator, to take account of the specific features of the current crisis. More detailed descriptions and justifications of the selected variables can be found in Roeger et al. (2019). We use quarterly data ranging from 1999Q1 to 2020Q4, which covers the period that Finland has been a part of the euro area. The source of the data is Statistics Finland, if not mentioned otherwise.

- **GDP Growth**: There is a clear link between growth in GDP and the economic cycle. As Roeger et al. (2019) state, GDP growth is not just correlated with the cycle but will generally also be correlated with the trend. We aim to reduce the correlation with the trend by using lagged annual GDP growth in the four quarters.[3]

[2] See also Toth (2021) for a similar multivariate unobserved components model to estimate potential output in the euro area.

[3] As explained by Roeger et al. (2019), growth in GDP is correlated with both the trend growth and the cycle. However, the correlation with trend growth can be reduced by using lagged GDP. The reasoning is that, e.g., if trend growth is represented by a random walk with drift, lagged GDP growth is uncorrelated with trend growth, but remains correlated with the cycle. Another benefit of using lagged GDP is that the first release of the GDP is typically revised substantially, and using lagged GDP will reduce the effect of revisions on the PCA output gap.

- **Price inflation**: The increase in consumer prices is a measure that is believed to include information about the economic cycle and the amount of resources available. For example, in a boom, prices rise rapidly because productive resources are fully utilized. In addition to demand factors, supply factors also affect inflation. In our article, the rate of increase in the harmonized index of consumer prices (HICP) is used as a measure of price inflation.
- **Wage inflation**: In the literature, the concept of non-accelerating wage rate of unemployment (NAWRU) refers to the lowest unemployment rate that can be achieved in conditions of stable wage growth. Wage inflation is expected to accelerate when unemployment falls below that level. Hence, wage inflation contains cyclical information of labour market conditions. We use annual growth rate of wages and salaries per hour worked as the measure of wage inflation.
- **Current account balance**: The current account balance (CAB) and it helps to take into account external influences affecting the output gap through several channels.[4] There may be a CAB surplus owing to low domestic demand and high levels of savings. But a CAB surplus may also be due to buoyant external demand. In both cases a surplus arises, although the economic situation is different. The current account balance is also affected by long-term trends, such as the impact of an ageing population on the need to save. In this article, the CAB is expressed as a proportion of nominal GDP.
- **Short-term unemployment rate**: Changes in short-term unemployment are mainly driven by cyclical variations.[5] Economic decline pushes up the figure for short-term unemployment. If a period of unemployment is prolonged and it becomes more structural in nature than short-term, that will be reflected in an increase in long-term unemployment. Short-term unemployment is defined as unemployment lasting less than a year.
- **Sentiment indicator**: We use the Economic Sentiment Indicator (ESI) from the European Commission Business and Consumer Survey for the analysis of the cyclical indicators. The reason for this is that the objective is to assess the economic situation, not GDP growth, from the angle of the output gap. In other words, the analysis

[4] It has been argued by Darwas and Simon (2015) that "… the Phillips curve relationship is not sufficient to trace back the output gap, because the effect of excess demand is not symmetric across the tradeable and non-tradeable sectors. In the non-tradeable sector excess demand creates excess employment and inflation via the Phillips curve, while in the tradeable sector much of the excess demand is absorbed by the trade balance." Therefore they recommend taking open economy aspects into account and incorporate current account balance in their model.
[5] The focus is on short term unemployment, since it can be seen as the more cyclical component of unemployment, whereas long term unemployment affects the trend and potential growth as well as the NAWRU.

is conducted in terms of levels and not growth rates.[6] The ESI represents the aim to describe the situation at the level of the entire economy and possibly even the state of the economy in the near future. The indicator is used widely; it has the advantage of a short publication lag and is not revised. Here we use a lagged observation of the confidence indicator, as this tends to forecast future developments in the business cycle (see, e.g., Mourgane and Roma, 2002; Gayer and Marc, 2018).

- **Capacity utilization rate**: If capacity utilization is higher than normal, the demand for a company's products may be assumed to be greater than what is usually the case in relation to production capacity, i.e. supply. Supply can also fluctuate, although changes in supply are normally slow. Capacity utilization is identified on the basis of surveys conducted with industrial enterprises (the European Commission Business and Consumer Survey[7]).
- **Service industry turnover**: During the COVID-19 pandemic it has been the service industries in particular that have suffered as a result of the considerable reduction in consumer mobility, the containment measures and voluntary changes in consumption behaviour. Gauging service industry activity during the current crisis is important. Since the capacity utilization rate captures cyclical variation in manufacturing, including a separate indicator for services is well justified, because the share of services of the total economy is high. An increase in turnover in the service industries also correlates strongly with the confidence indicator for services.

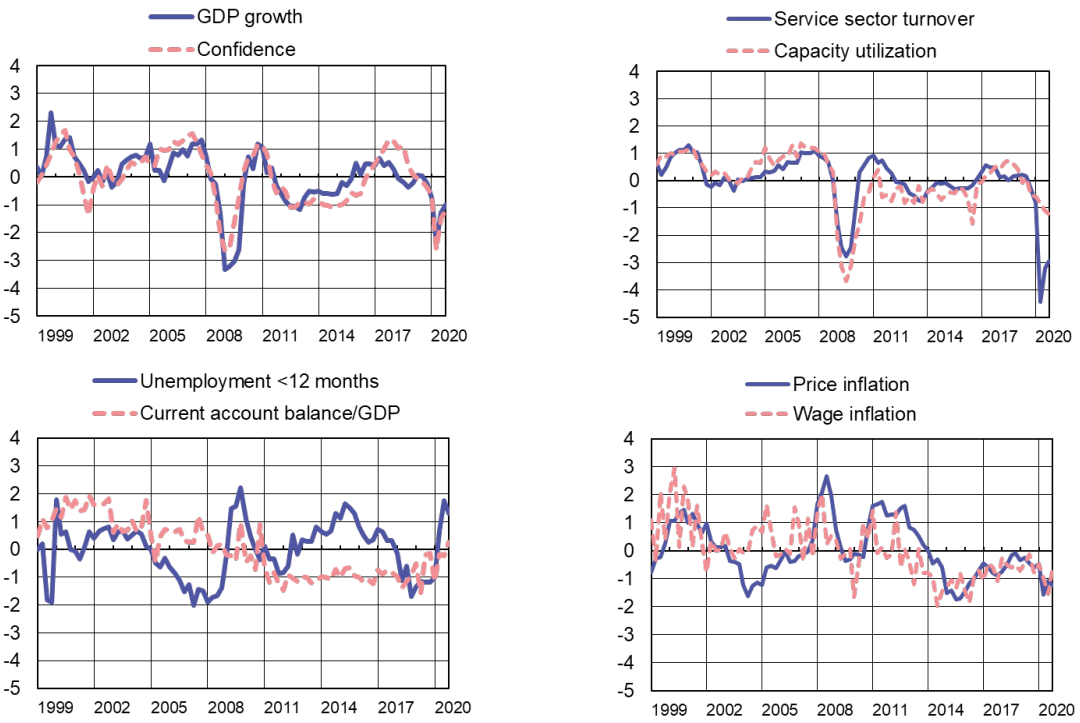
The cyclical indicators given in Figure 1 have been standardized, which enables comparison of the variation of the variables. In other words, the mean for all the series is 0, and most of the observations (approximately 95%) lie between +2 and -2. Observations outside these limits may be described as exceptional situations. Consequently, GDP declined to an exceptional extent during the spring 2020 (not lagged in Figure 1) , when COVID-19 hit, as did overall confidence in the economy and turnover in the service industries. In the third quarter of the year the economic difficulties are reflected in a sudden rise in short-term unemployment.

We can see from Figure 1 that economic growth was slower than average even before the COVID-19 crisis took off, and that growth then slowed less than during the financial crisis. Short-term unemployment was at a lower level than usual prior to COVID-19, as was the case prior to the financial crisis. During both crises, the short-term unemployment rate rose rapidly.

[6] As mentioned in Roeger et al. (2019), the overuse of confidence indicators can lead to a situation where level and growth signals are mixed. Therefore, we limit the number of confidence indicators to one

[7] https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/business-and-consumer-surveys_en

Figure 1. The COVID-19 crisis is reflected in different ways in the general cyclical indicators



The data in the graphs (1999Q1–2020Q4) have been normalised, so that the ways in which the series vary can be compared with one another. The mean figure for all the series is 0, and around 95% of the observations lie between +2 and -2.
Sources: Statistics Finland, European Commission and calculations by the Bank of Finland.

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When the present crisis started, price and wage inflation were subdued compared with the time preceding the financial crisis. The rate at which consumer prices increased was slower than average, and the dramatic decrease in demand generally in the spring of 2020 slowed the rise in prices even more. The wage inflation rate had also been slower than the average for the time Finland has been in the euro area and did not begin to accelerate until the eve of the crisis. The crisis has meant a reduction in price pressures.

The selected indicators suggest that the COVID-19 and financial crises have so far impacted the service industries and manufacturing very differently. During the global financial crisis, manufacturing capacity utilization plunged, but this time the decline has been less pronounced, at least so far. Turnover in the service industries, meanwhile, has plummeted to an unprecedented extent. There was a substantial decline in turnover during the financial crisis as well, but nothing like the complete halt in activity when the COVID-19 crisis hit in the spring. In general, however, both crises have had an adverse impact on both services and manufacturing.

3. Methodology

The common elements of the cyclical indicators shown above may be reduced to describe the general economic situation with the aid of Principal Component Analysis (PCA). This measures the combined dynamics of the indicators, i.e. the common factors affecting all of them at the same time. Formally, PCA is a dimensionality-reduction technique that may be used to extract the common patterns in a dataset. Principal components estimation has become a standard method in economic research, and has been applied in e.g. forecasting since the work of Forni et al. (2000) and Stock and Watson (2002).[8] Following the presentation of Roeger et al. (2019), the goal of PCA is to find components (PC) that are linear combinations of the original variables (X) that achieve maximum variance. A weight (w) is given to each of the variables. The *i*th principal component is defined as

$$PC_i = w_{1i}X_1 + w_{2i}X_2 + \cdots$$

The first component (PC_1) accounts for maximum possible variance, whereas the following components capture information not obtained by the first component. The components are uncorrelated with each other. Because PCA seeks to maximize the variance, it is sensitive to the scale of the variables. Therefore, the variables need to be standardized, as was done for the data presented in Figure 1.

Once the common components are extracted, the number of components employed in the analysis needs to determined, which means balancing between simplicity and completeness. The number of common components retained could simply be determined based on their eigenvalue. Kaiser's rule recommends keeping factors with an eigenvalue above unity, but other selection criteria have also been suggested by e.g. Bai and Ng (2002). However, in this paper, we follow the footsteps of Roeger et al. (2019) and focus on the first principal component, which is clearly cyclical.

4. Empirical findings

Our model describing the economic situation in Finland is based on the study by Roeger et al. (2019), supplemented with information obtained from the service industries. With this new method, and to facilitate the comparison to other estimates, the PCA-derived output gap based on the first component has been scaled to correspond to the standard deviation for the output gap estimate used by the Bank of Finland.

[8] For more details on PCA, we refer to Joliffe (2002).

Table 1. Total variance explained by principal components

Component	Initial eigenvalues		
	Total	Variance explained, %	Variance explained, cumulative %
1	3.9	48.5	48.5
2	1.2	15.2	63.7
3	1.0	13.1	76.8
4	0.8	9.7	86.4
5	0.5	5.6	92.0
6	0.3	4.2	96.2
7	0.2	2.1	98.4
8	0.1	1.6	100.0

Source: Calculations by the Bank of Finland

The first principal component accounts for half of the overall dynamic of the indicators (Table 1). The first component is by far the most important while the second component accounts only 15 per cent of the total variation. Hence, the first component can thus be referred to as depicting the cyclical change common to the variables around the normal economic situation, i.e. the output gap.

To validate the selection of the first principal component as a measure of the output gap, we check component correlation with the model variables for all components with eigenvalues higher than unity. The first principal component correlates strongly with the variables used in the model, and the signs for the correlation coefficients are as expected (Table 2). Generally, the stronger the correlation, the more useful the variable is in assessing the cyclical position[9]. The first principal component correlates most strongly with capacity utilisation (0.9), lagged overall economic confidence (0.8) and turnover in the service industries (0.8). The weakest correlations relate to price inflation (0.5) and current account balance (0.5). Between the two are wage inflation (0.7), short-term unemployment (-0.7) and lagged GDP (0.6). The second and third component have notably weaker correlation with the variables used in the model, and the signs for the correlation coefficients are often unexpected (Table 2)[10]. These findings confirm our choice of using only the first principal component in the output gap analysis.

[9] Trends in the variables or non-business cycle related cyclical variation could affect this.
[10] The second component has a high correlation with the current account balance (0.7) and the third component with price inflation (0.8).

Table 2. Correlation matrix of the observed variables and principal components

	Lagged GDP (t-4)	Short-term unemployment	Price inflation	Wage inflation	Capacity utilisation	External balance	Lagged confidence (t-1)	Turnover in services	Component 1	Component 2	Component 3
Lagged GDP	1.0	-0.3	0.3	0.3	0.5	0.3	0.3	0.3	0.6	0.3	-0.0
Short-term unemplyment	-0.3	1.0	-0.3	-0.3	-0.5	0.0	-0.6	-0.5	-0.7	0.4	-0.3
Price inflation	0.3	-0.3	1.0	0.5	0.1	0.1	0.2	0.4	0.5	0.3	0.8
Wage inflation	0.3	-0.3	0.5	1.0	0.4	0.5	0.5	0.4	0.7	0.5	0.1
Capacity utilisation in manufacturing	0.5	-0.5	0.1	0.4	1.0	0.4	0.8	0.7	0.9	-0.2	-0.3
External balance	0.3	0.0	0.1	0.5	0.4	1.0	0.3	0.2	0.5	0.7	-0.4
Lagged confidence	0.3	-0.6	0.2	0.5	0.8	0.3	1.0	0.8	0.8	-0.3	-0.2
Turnover in services	0.3	-0.5	0.4	0.4	0.7	0.2	0.8	1.0	0.8	-0.3	-0.0
Component 1	0.6	-0.7	0.5	0.7	0.9	0.5	0.8	0.8	1.0	-0.0	0.0
Component 2	0.3	0.4	0.3	0.5	-0.2	0.7	-0.3	-0.3	-0.0	1.0	0.0
Component 3	-0.0	-0.3	0.8	0.1	-0.3	-0.4	-0.2	-0.0	0.0	0.0	1.0

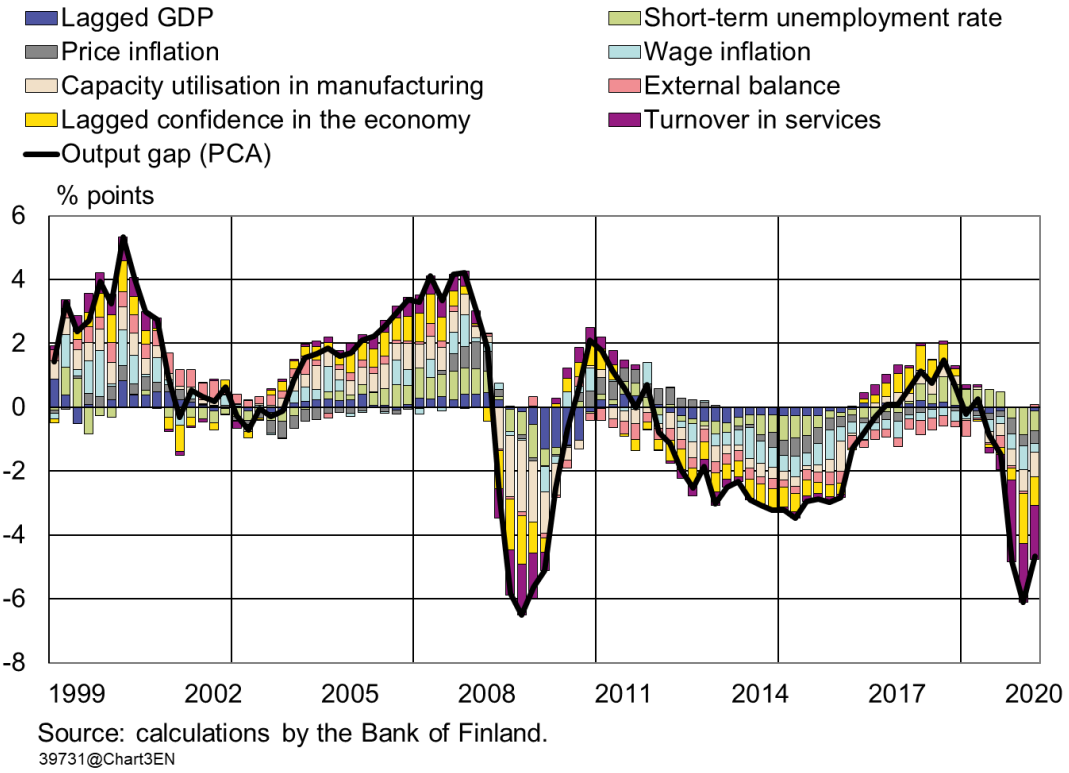
Source: calculations by the Bank of Finland

The advantage of the new method is that the effect of different cyclical indicators on changes in the output gap can be described in more detail than previously, and this therefore improves our understanding of the reasons for a particular cyclical downturn. The method confirms that the slowdown in activity observed in the service industries had, among various factors, the greatest single impact on the sudden widening of the output gap in the spring of 2020, when COVID-19 hit (Figure 2). The findings regarding the role of the service industry are robust regarding the variable used, since replacing service industry turnover with the service industry confidence indicator does not change the findings substantially.[11] The estimate of the output gap during the pandemic was also affected by increased difficulties in manufacturing, with the fall in capacity utilization and a general decline in confidence. After the spring of 2020, the increase in short-term unemployment had a notable effect on the estimate for the output gap.

The turnover in services also had an effect during the global financial crisis, but the most important driver was the decline in manufacturing capacity utilization (Figure 2). This highlights the advantage of the PCA methodology; it helps assess the role which different variables have on the output gap.

[11] We have also run a number of robustness checks to test the findings of our model. Most importantly, we find that the service industry turnover is indeed an important factor in assessing the depth of the output gap during the COVID-19 crisis (and also has an effect in other periods as well). Leaving the variable out results in a smaller widening of the output gap. Also, removing lags from ESI or GDP does not change the general finding that the decline in service turnover has the largest effect on the PCA output gap during the pandemic.

Figure 2. Decline in service industries widened the output gap in 2020

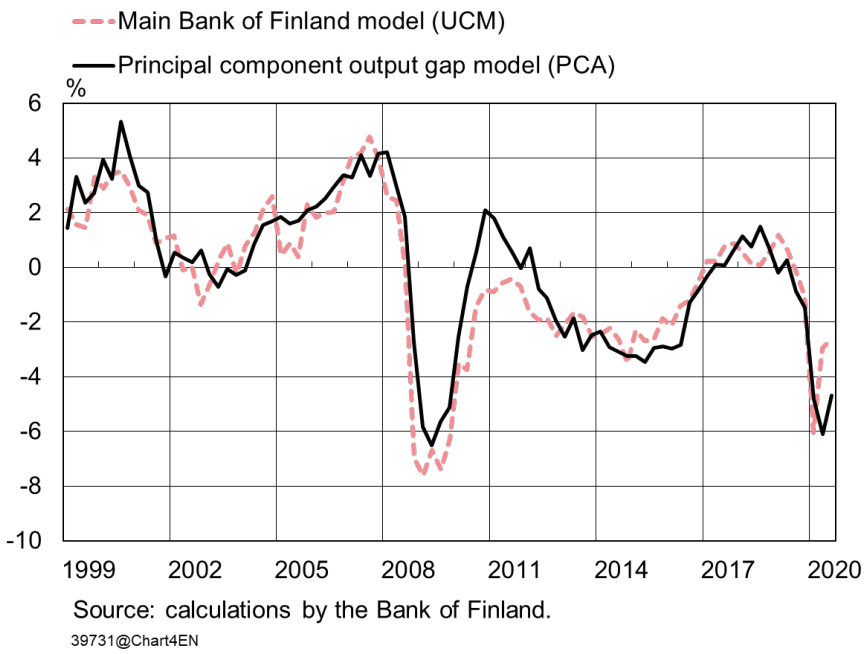


4.1 Comparison to alternative methods

The principal component model presented is only based on the common behaviour observed from the cyclical indicators and does not predetermine the links between the variables based on economic theory. The PCA output gap, however, produces a very similar picture to the Unobserved Components Model employed by the Bank of Finland (see Sariola 2019 for details), which also relies on economic theory (Figure 3). The model based on cyclical indicators would suggest that the Finnish economy had already cooled halfway through 2019 and was in fact more robust immediately after the financial crisis. In general, the differences between the estimates from these two methods are rather small. This gives some support for the plausibility of the UCM model estimates also during extraordinary times. However, revisions in the data may affect the findings of both models. [12] The main advantage of the PCA-derived output gap is that it allows us to assess the role of different variables at any point in time.

[12] We limit our analysis to exclude real time estimation and leave it to future work. For discussion on real time assessment we refer to e.g. McMorrow et al. (2015) and Orphanides et al (2002).

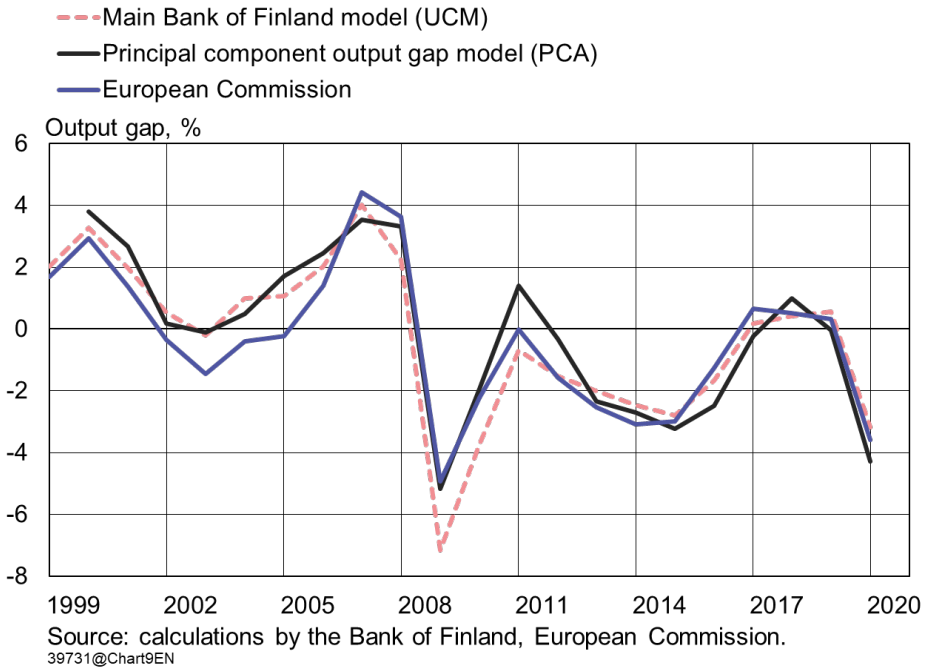
Figure 3. Quarterly output gaps based on UCM and PCA models



In addition, the PCA model's output gap is well in line with the European Commission estimate (European Commission spring 2021). Both yield large output gap swings in the history and set output gap similarly to negative territory in 2020 (Figure 4).[13] Also the trough of the output gap in the global financial crisis is interpreted similarly by the statistical PCA model and by the EU's commonly agreed methodology, which relies more on the economic theory (Havik et al. 2014). However, some small differences emerge. The peak of cyclical recovery in 2011 appears to be stronger by the PCA model compared to the Commission estimate. The stronger transitory rebound by the PCA model can be traced back in the data to improved services turnover growth, positive overall sentiment and accelerating headline inflation - all of them posting positive contributions in Figure 3 in 2011. This implies that the estimate for potential output given by the UCM and European Commission models are higher in 2011 than the PCA output gap would suggest. Overall, the PCA derived output gap is a useful comparison to the more established approaches. Furthermore, the similarity of the results between different models may be seen as indication that the output gap estimates are economically plausible.

[13] Comparison of the estimates is reported in annual terms while the European Commission does not publish quarterly ouput gaps.

Figure 4. Annual PCA output gap in line with European Commission estimate



It is worth noting that the principal component gap does not take (at least not full) account of changes in the trend rate of growth of the economic variables, which could lead to a misleading estimate of the output gap. The series used in the principal component gap model are concentrated around the mean value for the time Finland has been in the euro area. If the long-term trend rate of growth has slowed because of e.g. a fall in the working-age population and the slowdown in productivity growth, that can result in an excessively low estimate for the output gap at the end of the review period, as no account is taken of the decline in potential production growth. The same also applies to price and wage inflation in the periods examined. Since the global financial crisis, inflation expectations and actual inflation seem to have shown a slower trend. The Unobserved Components Model shown in figures 3 and 4, however, can take changes in the trend rate of growth into account to some extent, and the gap estimates do not appear to deviate so very much from one another.

5. Conclusion

In this article we present an alternative and flexible method to assess the output gap for Finland. Following the methodology used by Roeger et al. (2019), we employ Principal Component Analysis to extract a common factor from several cyclical variables. The common factor may be interpreted as a measure of the output gap. We complement the set of commonly used cyclical indicators with the index of turnover of service industries. The rationale for this is twofold. First, this allows to account for the specific features of the COVID-19 crisis, as service industries were most affected. Second, the set of indicators also include manufacturing capacity utilization, so it is reasonable to include a service industry specific indicator as well, as the service sector accounts for a major share of GDP in Finland.

The findings of our article indicate that the COVID-19 crisis caused a deep negative output gap in the of 2020, and a large part of the gap was explained by the difficulties emerging from service industries. Furthermore, our findings based on the PCA output gap are in fact rather similar to those obtained using an unobserved components model and the methodology used by the European Commission. In other words, statistical and theory based approaches produce relatively similar findings. As a final remark, the PCA derived output gap is a useful addition to the set of tools used in output gap analysis. It is a flexible method that allows us to assess the role of different variables on the output gap.

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