Questioni di Economia e Finanza

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a rationale for a revision of €-coin

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TRACKING ECONOMIC GROWTH IN REAL TIME DURING THE PANDEMIC: A RATIONALE FOR A REVISION OF €-COIN

by Valentina Aprigliano*, Simone Emiliozzi* and Marco Lippi§

Abstract

Covid-19 caused an abrupt disruption in the world economy and posed big challenges to macroeconomic and time-series analysis. The deep trough in the business cycle was unprecedented in momentum and magnitude, was not approached smoothly, and the pandemic shock was not heralded by any warning signal, as opposed to the run-up to crises triggered by economic factors. Differently from the global financial crisis and the sovereign debt crisis, when €-coin performed quite well, during the pandemic the indicator failed to track the intensity of the collapse and of the subsequent recovery in euro area economic activity. In this paper, we investigate the causes of the slow reaction of €-coin to the Covid-19 outbreak and we describe some revisions made to the indicator to get it back on track in estimating the medium- to long-run growth of the economy during the pandemic.

Contents

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1 Introduction[1]

Covid-19 outbreak hit the world unexpectedly in early 2020 and it took a severe toll on the economy. The world GDP collapsed by 4.4% in 2020 (-1.7 during the Global Financial Crisis in 2009) and the euro area slump was the hardest ever recorded since its foundation (-6.4% in the same period; -8.8% only in the first half of 2020).

Researchers and analysts faced two main problems. Firstly, the Covid-19 is an outlier process of unprecedented size and duration and has a one-way causal relationship with the economic system. Thus, it could not be heralded by the economic fundamentals or by the short-term macroeconomic indicators commonly used to foresee business cycle fluctuations. As the economy did not approach the trough smoothly, the econometric models based on mean-reversion and featuring smooth dynamics struggled to track the evolution of the economic activity in real time. Secondly, the enormous problems faced by national statistical offices' data collection process during the pandemic,[2] the unprecedented and heterogeneous health measures taken by the euro area countries and the continuously changing behavior of firms and consumers in response to Covid-19, challenged the real-time assessment of the evolution of the euro area economic conditions. This problem was made worse by the fact that the service sector, whose official statistics are typically less timely and comprehensive than those referred to manufacturing, has been the most harmed by the Covid-19 crisis hitherto.

Many studies in the literature tried to address these problems by setting up models which take into account non-linearity, tail-risks and fed on high-frequency and novel indicators (Carriero et al., 2020, 2021; Chetty et al., 2020; Lenza and Primiceri, 2020; Primiceri and Tambalotti, 2020; Antolin-Diaz et al., 2021; Lewis et al., 2021; Eraslan and Götz, 2021; Delle Monache et al., 2021; Woloszko, 2020).

All these problems hit harshly the class of dynamic factor models in general (Diebold, 2020; Ng, 2021) including €-coin (Altissimo et al., 2010), a monthly indicator of the underlying trend of euro-area GDP quarterly growth (GDP q-o-q onward) published by the Bank of Italy and CEPR since early 2000s.[3] This indicator normally provides a reliable signal on the medium- to long-run growth rate of the Euro Area economy in real time and a continuous monitoring has so far guaranteed its reliability throughout the cyclical phases. Like all econometric models trying to track the performance of macroeconomic systems in real time, €-coin may fail to immediately adapt when disruptive and abrupt events occur. As the latter usually cause important changes in the economy, constant monitoring

[2]In April 2020 the National Institute of Statistics (Istat) suspended the publication of the Italian firms and consumer sentiment indices since the pandemic hindered the monthly survey used for their construction.

[3]The monthly updates of €-coin are available at the CEPR and Bank of Italy websites.

and benchmarking of the index is indeed necessary. In particular, in the wake of the Great Financial Crisis (GFC, onward), €-coin was revised owing to major changes affecting many of the macroeconomic series used for its estimation: more than 30 per cent of these series were affected by the change of base year and by the switch to the new NACE classification (industrial production, turnover and prices). Moreover, the depth of the recession that had hit the euro area led to enlarging the database to incorporate new financial markets indicators.[4] Thanks to this revision, €-coin performed well in estimating the medium-to-long run growth even during the economic turmoils caused by the GFC in late 2007 and by the sovereign-debt crisis in 2011.

In the months following the Covid-19 outbreak, it was clear that €-coin was failing to grasp the extent of the euro area downturn as shown in Figure 1, where the dotted line indicates the GDP q-o-q and the blue line the indicator. Although €-coin is an estimate of the medium- to long-run growth rate, its tepid and slow reaction does not square well with the extremely volatile GDP data (further discussion is in Section 2). Figure 1 shows that at the end of March 2020, when the first lockdowns were enforced throughout the euro area, entailing a fall of 3.6% of GDP in 2020Q1 compared with the previous quarter, €-coin edged down to 0.13 from 0.28 in February. On average, in 2020Q2 €-coin recorded a modest -0.27 against a -11.4% drop of GDP in the same period. In August 2020, just after the release of the 2020Q2 GDP preliminary figure by Eurostat on July the 31st, €-coin reached its global minimum of only -0.64.[5] Following the rebound of the GDP in 2020Q3 (12.4%) published by Eurostat on October 30th, in November 2020 €-coin jumped to a record high of 1.18 (from -0.02 in October). This last figure was totally at odds with the 2020Q4 economic slowdown caused by the second wave of the pandemic. Were the €-coin not to be revised, it would have peaked in December at 1.64, the highest level ever, while the euro area economic activity was falling by 0.6% in 2020Q4.

Of course, this puzzling behaviour is not an exclusive feature of €-coin. For example, the Aruoba-Diebold-Scotti index (Aruoba et al., 2009) published by the Philadelphia Fed, provided noisier signals during the beginning of the pandemic and took time to get tuned to the rapid and unprecedented freefall of the economy (Diebold, 2020). In summer 2021, the New York Fed decided to temporarily suspend the publication of the nowcast updates from their model on US GDP growth (Bok et al., 2018) due to the unprecedented burst in volatility during the Covid-19. Its team is currently working on revising the baseline model to account for the pandemic shock.[6]

The present paper investigates the causes of the unsatisfactory behavior of €-coin during the pandemic and describes the revisions implemented to bring the

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[4]Further details are available in the Bank of Italy Economic Bullettin n. 53 published in July 2009.

[5]Until November 2020, €-coin was released at the end of the reference month and, as a result, it did not include the flash estimate of euro-area GDP published by Eurostat 30 days later than the reference quarter.

[6]Table 3 in the Appendix offers a non-exhaustive summary of publicly available models for business cycle analysis used by various institutions around the world.

Figure 1: €-coin before revision and GDP quarterly percentage growth
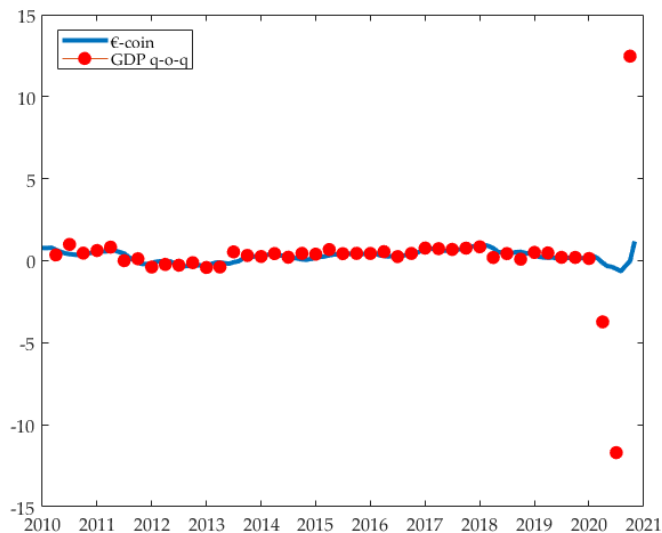
indicator on track again. In order to evaluate the improvements brought by the revision steps we compare the updated €-coin against its natural benchmark, namely a band-pass filter. The final revised €-coin provides the closest approximation to the band-pass filter not only during the Covid-19 period but also in previous sub-samples, minimizing the amplitude of the revisions when new macroeconomic data arrive. Moreover, the behaviour of the new €-coin is more consistent than that of the original indicator both with the drop of GDP during the first wave of the pandemic and with the temporary nature of the subsequent recovery, which reflected a strong mechanical rebound in the summer and was dampened by the resurgence of the contagion in autumn 2020.

The paper is organized as follows. Section 2 provides a preliminary assessment of the problem, by evaluating how much €-coin departed from its target, i.e. the medium- to long-run component of the euro area GDP q-o-q growth rate, and it pins down the causes; section 3 introduces the new version of €-coin and the revisions made to its database on both the cross-section and the time dimension; section 4 concludes.

2 A preliminary analysis of the problem

When Covid-19 hit the euro area in March 2020, the effects on the economy materialized rapidly and the real GDP in the first quarter dropped by 3.6%, before collapsing by 11.4% in 2020Q2, which was the most severe contraction ever. In order to pinpoint the turning points of euro zone's business cycle in the last 30 years we use the official chronology dates produced by the euro area Business

Cycle Dating Committee for the period 1988Q1-2020Q4.[7] Figure 2a shows the number of quarters elapsing between peaks and troughs in the time series of the euro area GDP. During the pandemic period, the economic activity contracted abruptly reaching the trough in a very short time compared with previous recessions. Symmetrically, as displayed in Figure 2b, the economy rebounded strongly within one quarter, even if this recovery was short-lived and extremely bumpy, due to the strong uncertainties related to the pandemic evolution.

The problem with €-coin was twofold. The indicator did not grasp the downfall due to the Covid-19 shock and its signal was difficult to interpret in light of the actual short-term evolution of the economy. Specifically, during the first and hardest months of the pandemic, €-coin provided a too mild negative signal on the state of the economy while, in autumn, its record high levels were at odds with the deterioration of the economic outlook caused by the second wave of the pandemic.

At the beginning of March 2020, Covid-19 started spreading rapidly in the euro area forcing several governments to impose strict containment policies, also in the form of prolonged lockdowns, that impacted significantly on economic activity (Hale et al., 2021). At the end of the month, €-coin estimated a 0.13% medium-to long-run growth, when it was clear that the restrictive measures adopted by the national governments to contain the contagion would have taken a heavy toll on activity already starting from the first quarter of 2020. In the first month of the pandemic, the level of €-coin was overall consistent with the dynamics of the macroeconomic indicators used for its estimation and which did not reflect yet the immediate fallout from the pandemic. The instantaneous drop of the financial indicators was not enough to steer downward €-coin, because the model discounted their information heavily due to the high volatility.

In April 2020, the negative signals begun to pile up, mainly from the qualitative surveys, while the hard indicators, such as industrial production, started to provide indications of huge economic losses only in May, due to the late release of the official estimates by the national statistical offices.

In June, all the available information pointed to an unprecedented collapse of GDP in 2020Q2 but, in the same quarter, €-coin stood on average at -0.27; it reached the minimum in August, at -0.64, when Eurostat published the flash estimate of GDP, which fell by 12.1% (-11.4% the final estimate).

In assessing the performance of €-coin one should consider that it is meant to estimate the smooth medium- to long-run component (MLRG henceforth) of the GDP q-o-q shorn of the fluctuations with a period shorter than or equal to 1 year, albeit deeply negative as the ones caused by the Covid-19 shock. In light of this, in real time €-coin seemed to fare well at the very beginning of the pandemic, before the release of the most important macroeconomic hard data like GDP, industrial production, trade statistics to name but a few. €-coin is indeed obtained by projecting via OLS the MLRG of the GDP q-o-q, c_t, on a

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[7]The most updated information on official dates for the turning points of euro area business cycle published by the CEPR-EABCN Euro Area Business Cycle Dating Committee is available at this link at the time of writing the paper.

Figure 2: Euro area business cycle in 1988Q1-2020Q4: peaks and troughs
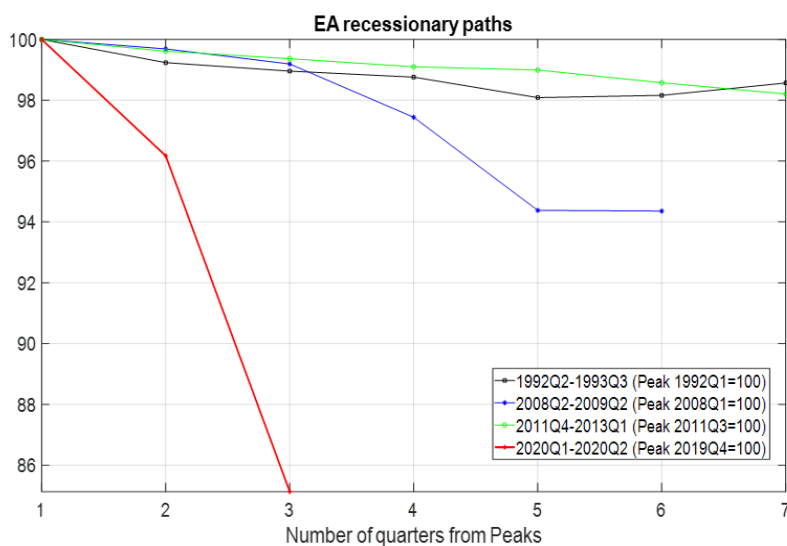
(a) Euro area recessionary paths
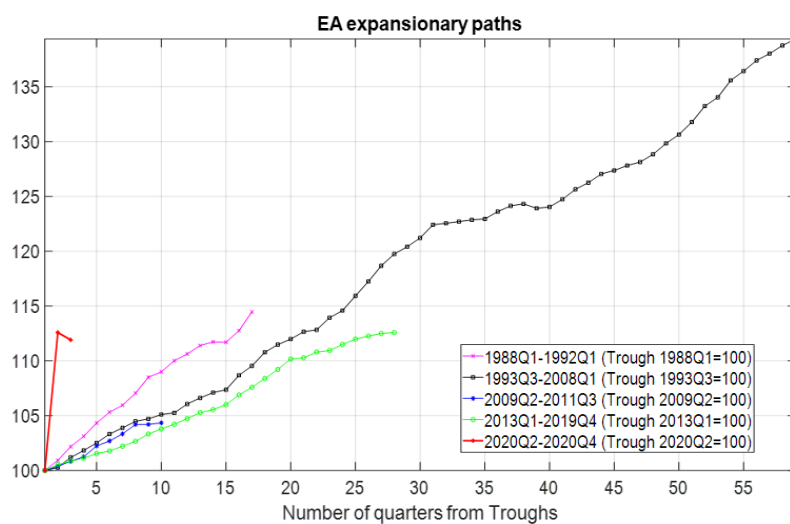
(b) Euro area expansionary paths

Note: Official recession dates available from the CEPR chronology for the period 1988Q1-2020Q4. GDP data are normalized to 100 in the starting quarter of each recessionary episode.

set of smoothed regressors, w_t, which are the generalized principal components extracted from the monthly dataset and specifically designed to minimize the short-run component:[8]

$$\hat{\Sigma}_\phi v_k = \lambda_k(\hat{\Sigma}_\chi + \hat{\Sigma}_\zeta)v_k \tag{1}$$

where v_k and λ_k are the generalized eigenvector and eigenvalue, respectively, for $k = 1, \ldots, N$ and $\hat{\Sigma}_\phi$, $\hat{\Sigma}_\chi$ and $\hat{\Sigma}_\zeta$ are consistent estimates of the covariance matrices of the medium- to long-run common component, of the common and idiosyncratic components, respectively, extracted from the correspondent spectral density matrices. €-coin is therefore estimated as follows

$$\hat{c}_t = \hat{\mu} + \hat{\Sigma}_{cw}\hat{\Sigma}_w^{-1}w_t \tag{2}$$

In fact, as shown in Table 1, the increase of the total variance of the GDP in the first two quarters of 2020 almost totally reflects the increase of the contribution of the short-term components, which are filtered out by €-coin. Figure 3 displays the distribution of the variance of GDP q-o-q by frequency components. After Covid-19, the most volatile components of GDP have contributed mostly to the huge increase in the overall variance.

Table 1: Frequency-domain variance decomposition of the euro area GDP q-o-q in "medium to long-run growth" (MLRG) and "Short Term" (ST) components.

Period pre Covid-19 **1988:Q1-2019:Q4**	Var. GDP Tot.	0.3
	Var. GDP MLRG	0.1
	Var. GDP ST	0.2
	Signal-to-noise ratio [1]	31%
Period post Covid-19 **1988:Q1-2020:Q2**	Var. GDP Tot.	1.7
	Var. GDP MLRG	0.3
	Var. GDP ST	1.4
	Signal-to-noise ratio[1]	18%

[1] The *signal-to-noise ratio* is defined as the ratio between the variance of the MLRG component $\hat{c}_t$ and the total variance of the euro area GDP q-o-q.

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[8]See Altissimo et al. (2010) for technical details on the estimation of €-coin.

Figure 3: Spectrum of the euro area GDP growth rate estimated before and after the Covid-19 crisis
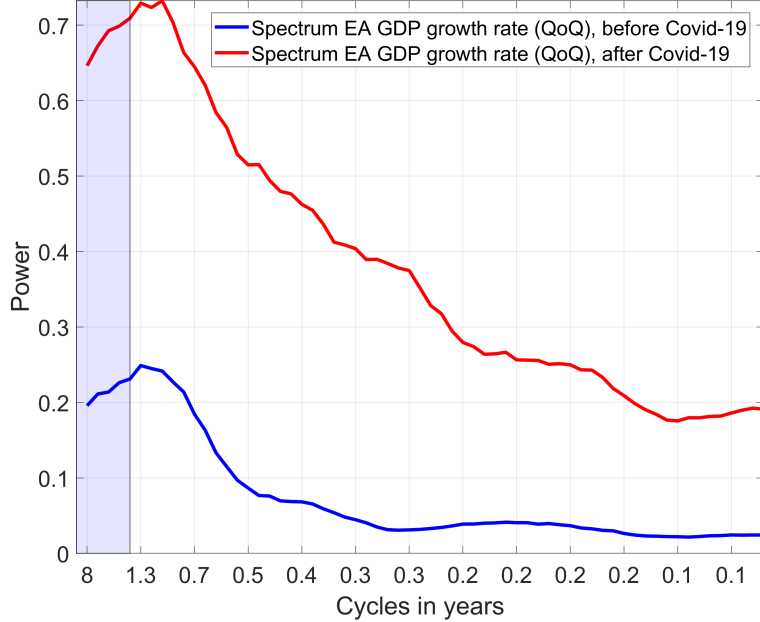
Note: spectrum of the euro area GDP growth rate estimated on the sample 1988Q1-2019Q4, before the Covid-19 recession (blue line); spectrum of the euro area GDP growth rate estimated on the sample 1988Q1-2020Q2, including pandemic observations (red line). The shaded area highlights the euro area GDP "medium- to long-run growth" (MLRG) component; values on the right of the shaded area are the short term frequencies (ST) with periodicity lower than one year.

Nonetheless, the gap between €-coin and GDP's figure was so wide that further elaboration was deemed necessary. To investigate this discrepancy, the euro area GDP's time series was extended until 2023 by envisaging three different scenarios to compute the €-coin benchmark, namely the band-pass filtered series of euro area GDP q-o-q.[9] In a severe scenario, GDP would have shrinked in 2020Q4[10] and 2021Q1, before starting a gradual recovery; in a mild scenario, GDP would decrease slightly in Q4 and then would have recovered strongly since 2021Q1; in a central scenario GDP was assumed to have grown by 0.3% as the average pace in the last decade. For each of the three hypothetical scenarios we computed the band-pass filtered series of the euro area growth rate during the pandemic period. Irrespective of whether we assume a more prolonged crisis or a temporary turmoil, the benchmark records a much deeper fall than the trajectory estimated in real time by €-coin in 2020Q1 and 2020Q2, as shown in Figure 4.[11]

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[9]The two-sided band-pass filter used to estimate the benchmark is not reliable at the end of the sample; therefore, we extended the series of the GDP well beyond the available figures.

[10]While preparing the analysis for this work, the preliminary estimate of GDP quarter-on-quarter growth rate in 2020Q4 was not available yet.

[11]Unlike €-coin, the benchmark is not estimated in real time, therefore the preliminary figure of GDP is assumed to be promptly available in the reference quarter. However, this does not

Figure 4: Band-pass filtered series extracted from the euro area GDP q-o-q (continuous lines) and

euro area GDP q-o-q in the three scenarios (dotted lines)
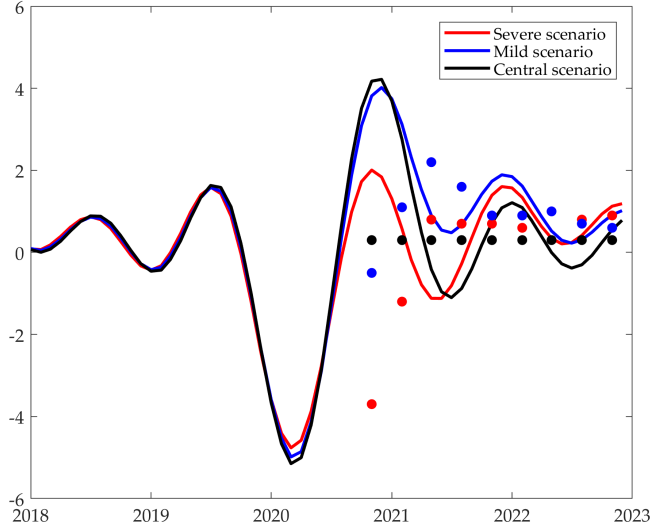
Note: the figure shows the three scenarios (severe, central and mild) for GDP growth till 2023Q3. The three continuous lines are the associated band-pass filtered series. In the three scenarios the latter reach values lower than -4% in 2020Q1 and 2020Q2. In the same two quarters the real time estimates of €-coin were only slightly negative.

We investigated the causes of such a discrepancy between €-coin and its benchmark by conducting two counterfactual exercises. The first explores how the econometric model and the nature of the euro area GDP contributed to this excessive smoothing displayed by the original €-coin. Instead of using OLS as in equation (2), the MLRG component c_t was projected on the space of the common factors using the Least Absolute Shrinkage and Selection Operator (LASSO), as done for the Italian counterpart of €-coin, Ita-coin (Aprigliano and Bencivelli, 2013). As a result LASSO would have induced less smoothing than OLS performed in the low frequency band used to estimate €-coin. As shown in Figure 5, had been estimated with LASSO, in August 2020 €-coin would have fallen more than the original version of the indicator, to -1.3, rather than to -0.64.

The second counterfactual exercise showed that the behavior of €-coin can be partially explained by the inherent smoothness of euro area GDP, which is a weighted average of member states GDPs. If we substitute the euro area GDP with those of the first three major economies (Germany, France and Italy) *ceteris paribus*, we obtain three single-country coincident indicators of economic activity, which singularly decline more than the original €-coin: -1.1 for France, -1.2 for Germany and -1.7 for Italy (see Figure 6).

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affect the size of the drop but only its timing, because the benchmark reaches its minimum between March and April, i.e. some months before €-coin.

Figure 5: €-coin: pre-revision official and model-counterfactual estimates
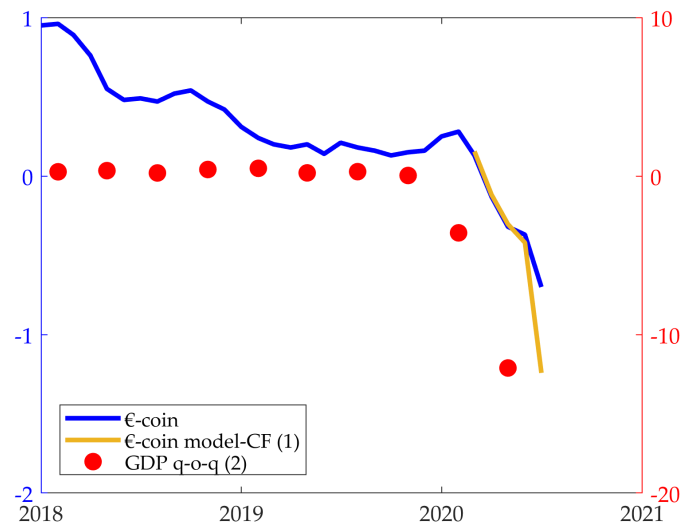
Note: (1) €-coin model-CF is the counterfactual indicator estimated by using LASSO; (2) right-hand scale.

In light of these results, a third direction of inquiry concerned the building blocks of the econometric model. In order to visualize the €-coin instabilities gen-

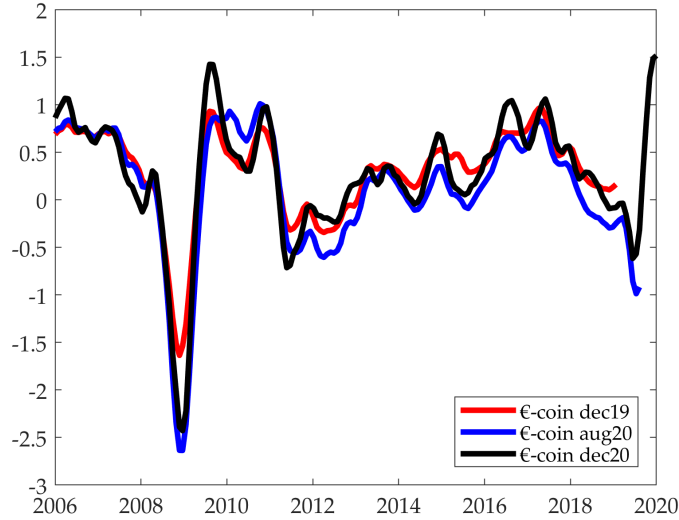Figure 6: €-coin: official and countries' GDP counterfactual estimates
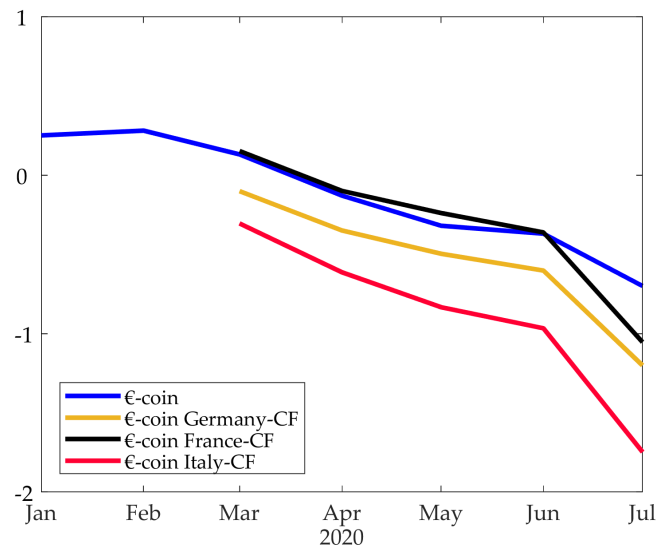
Note: the counterfactual €-coins are estimated by using each country's GDP as the dependent variable instead of euro area's GDP.

erated by the pandemic, Figure 7 plots the ex-post estimates for three important points in time: (i) December 2019, before the Covid-19 outbreak; (ii) August 2020,

after the release of the flash estimate of the GDP for the 2020Q2 (-12.1%); (iii) December 2020, after the release of the GDP figure for the 2020Q3 (12.4%). The

Figure 7: €-coin estimated ex-post in December 2019, August 2020 and December 2020

ex-post estimate of the official €-coin, obtained after the strong fall of GDP in 2020Q2, was revised substantially downward for both recent and past values of the indicator. After the strong GDP rebound in 2020Q3, its profile shifted upwards to the pre Covid-19 level (close to the December 2019 *ex-post* estimate), and it became more volatile reaching a peak at the end of the sample.

We explored how this huge revisions of the signal induced by the pandemic shock can be explained by the instability of the estimated smooth factors and of their loadings (in equation 2). The former changed substantially, while the latter varied somewhat. Figure 8 displays the time variation of the projection coefficients (loadings) in the recursive sample from December 2019 till November 2020. The constant term and the coefficients associated with the most relevant factors (i.e. $F1, F2$ and $F5$, that explain a large fraction of the variation of the indicator, account for the dynamics of firms' and households' confidence indicators together with information coming from some hard data such as industrial production and car registrations) exhibited instabilities around the two most important GDP's releases during the Covid-19 period: at the end of July 2020 with release of the flash estimate for 2020Q2 and at the end of October 2020 with the one of 2020Q3.

Figure 9 reports the temporal evolution of the €-coin six smooth factors estimated using a recursive sample from December 2019 to November 2020. The first smooth factor (F1), which explains a large fraction of €-coin and is associated

Figure 8: €-coin projection coefficients for the constant term and for the six smooth factors $(F1, \ldots, F6)$ estimated in real-time from December 2019 till November 2020.
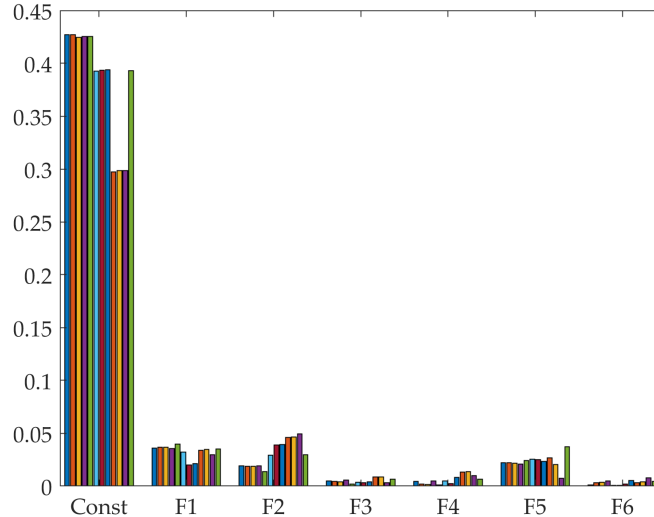
Note: the bars represent the estimated projection coefficients (including the constant term) made in each month, from December 2019 until November 2020, between the euro area GDP MLRG component and the six smooth common factors $(F1, \ldots, F6)$.

with firms' and households' confidence surveys of the main euro area countries, displayed high instability since it was strongly revised backwards after the release of the GDP in 2020Q1 at the end of April. The same pattern emerged for the second factor (F2), that tracks the signal from the surveys about future economic conditions and other forward looking financial variables. Finally the fifth factor (F5), highly correlated with the industrial production and car registrations in the euro area countries, started to peak strongly at the end of the sample, following the high volatility that characterized the short-term economic indices during the summer in 2020.

3   The new €-coin indicator through the revision steps

The revision of €-coin was addressed by modifying its original information set following three main steps. Firstly, more short-term indicators on the activity in the service sector were included. Secondly, we screened the dataset and removed the redundant variables as suggested in Boivin and Ng (2006): the updated dataset is available in Tables 4 and 5. Finally, we experimented with the length of the estimation sample in order to understand which was most suitable to represent the latest developments in the euro area business cycle. The following subsections deal with the details of each stage of the revision.

Figure 9: €-coin smooth factors estimated on a recursive sample from December 2019 till October 2020.
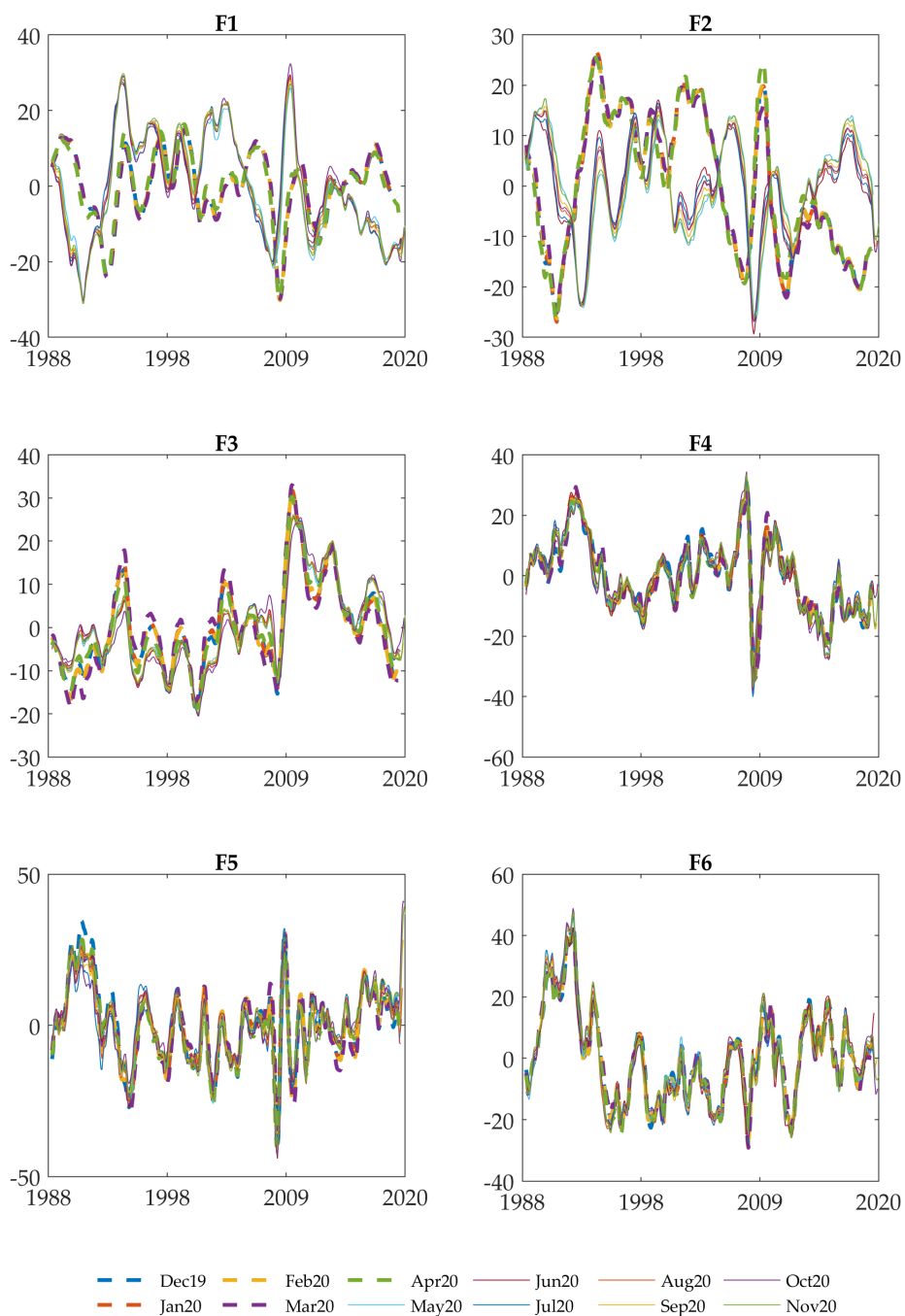
Note: The figure reports the temporal evolution of the €-coin six smooth factors $(F1, \ldots, F6)$ estimated using a recursive sample from December 2019 to November 2020. As new observations entered the model after the blow of the pandemic, the estimates of the most relevant factors for shaping €-coin got highly unstable, inducing more noise in the model.

3.1 Inclusion of the services sector Purchasing Managers' Indices

When €-coin was constructed in early 2000s, gathering short-term and timely indicators on the activity in services was challenging, notwithstanding the growing importance of the sector as a share of the total economy. The dataset originally was not including any indicator targeting the service sector directly, which ended up being under-represented against manufacturing. The latter is a strong engine of the euro area economy, adding up to almost 20% of the total activity, and it activates the service sector itself, whose dynamics was also partially approximated by the financial variables used in the model. For these reasons, during pre-pandemic times, €-coin has always performed well in tracking the MLRG of the euro area economy, grasping the timing and the depth of both recessions and recoveries in real time.

The Covid-19 shock hit mainly the euro area countries services sector, spilling over to manufacturing to a lesser extent. This ignited the issue of enhancing its weight in the dataset used for the estimation of €-coin. The bundle of short-term indicators on the service sector at the euro area level is still limited nowadays but there are some variables, such as the Purchasing Managers' Indices (PMI) provided by Markit, which match up well with the features of timeliness and reliability required by €-coin's model.[12] As a first step of the revision we have thus included the "business activity" component of the services PMI for Euro Area, Germany, France and Italy. Figure 10 shows that the estimated €-coin with the augmented dataset (black line) followed a downward trend throughout the pandemic sample up to October 2020, consistently with the weakness of the sector if we exclude the temporary revamp in the summer. Feeding the dataset with the service sector indicators was then necessary, but not enough to get €-coin back on track, calling for further action, as described in the following sections.

3.2 Getting rid of redundant information in the dataset

The factor models allow to exploit the information from a large panel of data for the macroeconomic analysis in an efficient way. The original dataset of €-coin used to include many blocks of variables from major euro countries for the real economy, the financial sector and prices with extremely fine breakdowns. For instance, there were many components of the industrial production index and of business confidence. This choice was justified by a classical result in the factor analysis literature where dataset with a large cross-sections were favoured to consistently estimate the common factors.

However, Boivin and Ng (2006) questioned whether large cross-section panels are always better for factor analysis in economic applications. They find that within an "approximate factor model", where the idiosyncratic errors can be contemporaneously weakly serially and cross-sectionally correlated, more data might not be desirable and the extracted factors might be less useful for forecasting.

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[12] https://www.markiteconomics.com/.

Figure 10: Comparison between the original €-coin and the one estimated with services PMI included
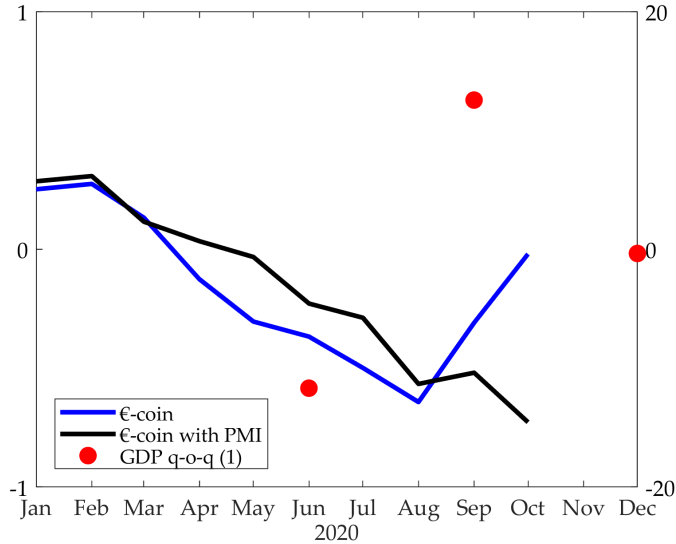
Note: original €-coin (blue line), €-coin estimated including the services PMI (black line) and euro area GDP q-o-q (red dots); (1) right-hand scale.

Since €-coin's dataset is assumed to have a generalized factor structure with correlated idiosyncratic components, we deemed suitable screening the variables used for the estimation and we got rid of redundant information. After the inclusion of the PMI for services in the previous step, we thoroughly selected the information in the blocks of industrial production and of the soft indicators, which represent the most important information driving the bulk of the covariance in the dataset. All country- and sector-specific components of the industrial production were excluded, saving only the total index for the euro area, which is a weighted average of the indices of its member states. We also reduced the cross-section dimension of the block of the surveys on business climate in the manufacturing sector from 32 series to 7, keeping only the Economic Sentiment Indicator for the euro area together with firms' and households' confidence indicators for Germany, France and Italy (together accounting for almost 50% of the total euro area's GDP). Tables 4 and 5 in the Appendix collect the detailed list of variables included in the new dataset of €-coin.[13] As shown in figure 11, the €-coin based on a cleaned up dataset looks more consistent with the downturn in spring 2020 and the subsequent recovery, that would have been hampered by the resurgence of the pandemic early in autumn 2020.

3.3 Shortening the estimation sample

€-coin is a monthly indicator estimated over a recursive sample that used to start on January 1988. When €-coin was constructed in the early 2000s, a 20-years

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[13]The old dataset of €-coin is available upon request.

Figure 11: €-coin without redundant information included

Note: original €-coin (blue line), €-coin estimated with cleaned dataset and the services PMI (black line) and euro area GDP q-o-q (red dots); (1) right-hand scale.
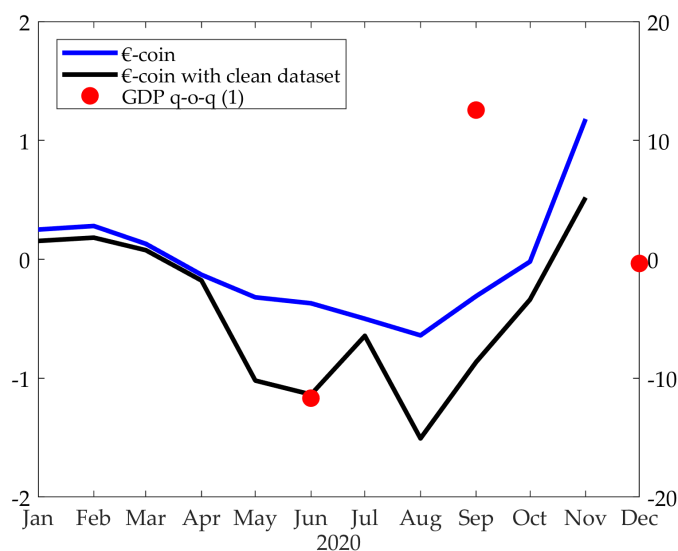
length of the sample was considered suitable to provide a reliable estimate of the smooth indicator with a medium- to long-run perspective. However, when the sample becomes too long the results of the analysis may be misleading for two main reasons. Firstly, the more the sample enlarges the more the smoothing effect becomes pervasive. The collapse of the economy in the first half of 2020 due to the Covid-19 outbreak is a tail-event in comparison with past recessions, therefore the regression model, estimated on a smooth and low frequency band, dampens it. Secondly, the dynamics of euro area's GDP growth rate changed significantly since the early 2000s, as confirmed by the structural break test of Bai and Perron (2003).[14] In the last decade, growth was sluggish and the deep recessions sparked by the Global Financial Crisis in 2007 and by the Sovereign Debt Crisis in 2011 contributed to boost its volatility.

Using the new dataset for the estimation of €-coin, that excludes the redundant variables and includes the PMI for the service sector, we assessed which length of the sample was more suitable based on two criteria: the stability of the signal and its distance from the benchmark, namely the two-sided band-pass filter computable ex-post. We tested three starting years for the sub samples: 1997 (€-coin 97), when the pace of the enforcement of the monetary union accelerated, 2000 (€-coin 00) and 2003 (€-coin 03), which is the minimum length to a) include in the estimation sample the fluctuations caused by the GFC and the sovereign-debt

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[14]Running the structural break test proposed in Bai and Perron (2003) on the euro area GDP growth rate series from January 1988 till December 2019 (the Covid-19 period was excluded from the analysis), we found at least one structural break at the end of 1999. This is just preliminary evidence of differences in the euro area growth rate between more recent years and the 1980s-1990s years.

crisis without biasing the estimates negatively[15] and b) to save a decent number of observations to evaluate the performance of the indicator.[16]

Table 2 shows the average of the monthly revisions and the mean squared distance of each €-coin from the benchmark.[17] The sample was split into 5 sub-samples to investigate the performance of €-coin during the most critical phases of the euro area economy in the last decade: the Global Financial Crisis; the Sovereign Debt Crisis; the following recovery; the slowdown in 2018 and 2019 mostly due to the trade war between US and China; the Covid-19 outbreak during the beginning of 2020.[18]

In general, during periods of great macroeconomic instability, €-coin tends to revise more the historical estimates and its distance from the benchmark increases. The old version of €-coin, which was published until November 2020 (€-coin in

Table 2: Mean of the revisions and distance from the band-pass filter benchmark

| | GFC 2008.Q1 - 2009.Q1 | | SDC 2011.Q1 - 2013.Q1 | | Recovery 2013.Q2 - 2017.Q4 | | Slowdown 2018.Q1 - 2019.Q4 | | Covid 2020.Q1 - 2020.Q2 | |
	rev	MSD[a]	rev	MSD	rev	MSD	rev	MSD	rev	MSD
€-coin	0.026	0.88	0.018	0.16	0.022	0.21	0.048	0.48	0.287	4.03
€-coin 97	0.03	0.91	0.02	0.18	0.02	0.27	0.05	0.42	0.73	3.95
€-coin 00	n.a. [b]	n.a.	0.03	0.18	0.03	0.26	0.06	0.41	1.07	3.90
€-coin 03	n.a.	n.a.	n.a.	n.a.	0.03	0.23	0.06	0.41	0.92	3.92

[a] MSD: mean squared distance.
[b] n.a. stands for *not available* because we use a 10-years estimation window.

the first row of Table 2), provided the most reliable and accurate estimate of the MLRG before the pandemic crisis. Even during the Global Financial and the Sovereign Debt Crisis, it tracked closely the benchmark and revised the estimates backward on average 15% less than the competitors.

In the two years 2018-2019, the euro area economy lost steam, owing to the slowdown of the manufacturing activity against the positive momentum of the service sector. In this period the distance between €-coin and its benchmark became a bit wider than that between the latter and €-coin-2000. This result may reflect reasonably the inclusion of more information on services. Indeed, from the summer 2018 until the end of 2019, manufacturing and services PMI started to decouple, with the latter overcoming the former.

Among the competitors, €-coin-2000 provides the best trade-off between the stability of the signal and its accuracy; in the sample 2018.Q1-2019.Q4 and during the first phase of the pandemic it turns out to be closer to the benchmark than €-coin, albeit with a higher monthly revisions mean with respect to the original index. In June 2020, the original €-coin signalled a milder contraction of the

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[15]The negative bias of the estimates may occur if the starting date of the estimation sample is too close to the turmoils.

[16]The estimation window is 10 years.

[17]The band-pass filter benchmark is estimated from January 1981 to December 2021 cutting the first and the last 10 observations.

[18]In order to get reliable estimates of the index in each sub sample the length of the estimation sample is set to 10 years. Hence the results are not available for all the €-coins in all the sub samples.

MLRG component (-0.37). Instead €-coin-2000 was doing a better job in estimating the MLRG component since, in the same month, it would have indicated a contraction greater than -1.0, closer to the "true value" of a -4.0% fall reached by the benchmark. In August 2020, when Eurostat published the preliminary estimate of the euro area GDP growth in 2020Q2 (-12.1%), €-coin fell to -0.64 against -1.58 of €-coin-2000 and -2.75 of the benchmark. In autumn, the second wave of the pandemic cooled the expectations of a steady recovery. In November, Eurostat published the preliminary estimate of 2020Q3 GDP growth rate (12.7%), which pushed €-coin up to 1.18 while €-coin-2000 rose to 0.13, signaling that some negative forces were hindering the pace of the recovery.[19]

3.4 The new €-coin: revision steps summary

We opened the black box to investigate the causes of €-coin's puzzling behaviour during the Covid-19 crisis. We found that the smoothing filter behind €-coin played a role in excessively dampening the large fluctuations of the economy during the pandemic but it was not the only cause of the unsatisfactory dynamics of the indicator. Therefore, we analyzed how and to what extent common factors and regression coefficients contributed in extracting the economic activity signals during the Covid-19 pandemic.

After this thoughtful preliminary diagnosis, we undertook three steps of revision. In the first one, we included more information on the activity in the services sector (Purchasing Managers' Indices), which represents a high share of the total economy and it was particularly struck during the pandemic. Secondly, we screened the dataset and removed redundant information. Finally, the length of the estimation sample was shortened, starting from 2000 instead of 1988.

The new version of €-coin provides the best trade-off between stability of the signal and accuracy, measured as the proximity to the benchmark, i.e. a band-pass filter.

As shown in Figure 12, the behavior of the new €-coin tracks more closely the benchmark estimated via a band-pass filter than the original indicator.[20] Moreover, although €-coin is a smooth indicator - meant to estimate the medium-to-long-run component of the GDP evolution - the new version of the indicator is more consistent with the actual dynamics of activity during the pandemic. In particular, it captures better than the original indicator both the severity of the drop in the first wave and the temporary nature of the subsequent strong rebound in the summer, which was dampened by the resurgence of the contagion in autumn 2020.

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[19]The performance of €-coin-2003 is apparently satisfactory, but this result is biased by the fact that the validation sample does not contain any economic recession except the one generated by the pandemic, that has peculiar characteristics.

[20]In order to obtain a fair comparison, we assume that the official figures of GDP are not available promptly for the estimation of the band-pass benchmark, but with a three-month lag as in the real-time estimation of €-coin.

Figure 12: New and old version of €-coin together with the band-pass benchmark
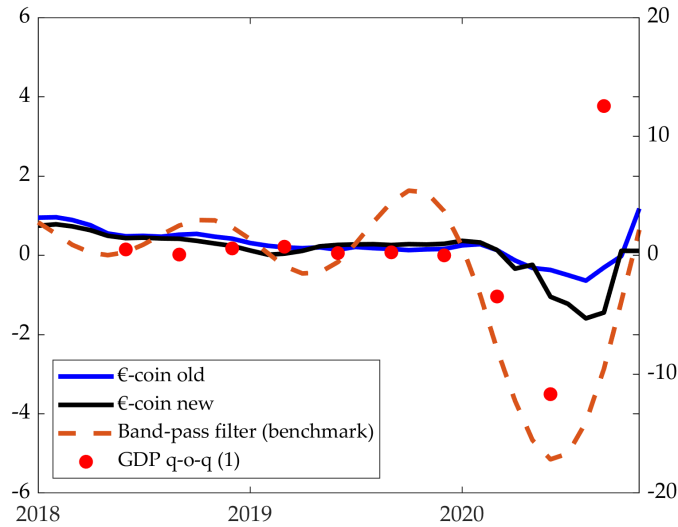
Note: original €-coin (blue line), final €-coin estimated with all revisions steps (black line), estimated band-pass filter (dotted orange line) and euro area GDP q-o-q (red dots); (1) right-hand scale.

4 Conclusions

Covid-19 disrupted the world economy in an unprecedented way posing new challenges to macroeconomic real-time analysis and forecasting. Adjustments are deemed necessary to make econometric models more responsive to big fluctuations of the activity caused by the pandemic.

In this paper we have documented the revision process to €-coin, the indicator of the medium- to long-run growth of the euro area economy, developed by the Bank of Italy and CEPR early in 2000's (Altissimo et al., 2010). When the pandemic hit the euro area in February 2020, €-coin dampened the big fluctuations in the economy excessively and signalled just a modest and unrealistic contraction of the business cycle in the second quarter of 2020. In the autumn 2020, €-coin peaked, after the release of the flash estimate of the GDP q-o-q growth in 2020Q3, in a context where the resurgence of the number of infections would have hampered the prosecution of the recovery.

This recent disappointing performance of the index was in sharp contrast with the very good tracking of economic developments in real time during the GFC and the sovereign-debt crisis, calling for a thorough revision of €-coin.

In order to evaluate the improvements brought by the revision process we compare the updated €-coin against its natural benchmark, namely a band-pass filter. The revised version of €-coin provides a good approximation to the band-pass filter not only during the Covid-19 period but also in previous sub-samples. Moreover, its behaviour is more consistent than that of the original indicator with the dynamics of actual GDP, both during the first wave of the pandemic and with

the subsequent phases.

The challenges posed by Covid-19 to econometric modeling have further to be studied and deserve more elaborations. The pandemic period has been very long and it tends to dominate the covariance among the macroeconomic indicators. Therefore, it is particularly tricky to understand how to handle the models not only to obtain reliable projections during the turmoil but also to stabilize the estimates in the subsequent periods, when the sanitary emergency will fade.

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Appendix

Table 3: Publicly available models for business cycle analysis

Model	Country	Type	Institution	Frequency	References
€-coin	Euro area	MLRG	Banca d'Italia	Monthly estimate	Altissimo et al. (2010)
Nowcasting model Fed	Euro area & Major countries	Nowcast	Fed Board	Weekly estimate	Cascaldi-Garcia et al. (2021)
Euro-Sting	Euro area	Nowcast	Banco de Espana	Weekly estimate	Camacho and Perez-Quiros (2010)
Confcommercio nowcasting model	Italy	Nowcast	Confcommercio	Monthly estimate	Congiuntura Confcommercio
Ita-coin	Italy	MLRG	Banca d'Italia	Monthly estimate	Aprigliano and Bencivelli (2013)
ITWEI	Italy	Nowcast	Banca d'Italia	Weekly estimate	Delle Monache et al. (2021)
Aruoba-Diebold-Scotti index	US	Nowcast	Philadelphia Fed	Daily estimate	Aruoba et al. (2009)
CFNAI index	US	Nowcast	Chicago Fed	Weekly estimate	Brave and Butters (2014)
GDPnow	US	Nowcast	Atlanta Fed	Weekly estimate	Higgins (2014)
GDPplus	US	Nowcast	Philadelphia Fed	Monthly estimate	Aruoba et al. (2016)
Nowcasting model Fed	US	Nowcast	NY Fed	Weekly estimate	Bok et al. (2018)
WEI	US	Nowcast	NY Fed	Bi-weekly estimate	Lewis et al. (2021)
Monthly GDP	UK	Monthly National Accounts	ONS	Monthly estimate	ONS website
German WEI	Germany	Nowcast	Bundesbank	Weekly estimate	Eraslan and Götz (2021)
OCSE WEI	OECD & G20 Countries	Nowcast	OCSE	Weekly estimate	Woloszko (2020)

Table 4: Dataset of the new €-coin

MNEMONICS[a]	TITLE	BLOCK	COUNTRY
ITMHIST	FTSE ITALIA MIB STORICO	SP	ITALY
DJEURST	EURO STOXX	SP	INTERNATIONAL
DAXINDX	DAX 30 PERFORMANCE	SP	GERMANY
FRCAC40	FRANCE CAC 40	SP	FRANCE
S&PCOMP	S&P 500 COMPOSITE	SP	US
FTSE100	FTSE 100	SP	UK
IBEX35I	IBEX 35	SP	SPAIN
EIBOR3M	EBF EURIBOR 3M DELAYED	INT	EURO AREA
BBGBP3M	IBA GBP IBK. LIBOR 3M DELAYED	INT	UK
BMBD03Y	BD BENCHMARK 3 YEAR DS GOVT. INDEX	INT	GERMANY
BMBD10Y	BD BENCHMARK 10 YEAR DS GOVT. INDEX	INT	GERMANY
BMUS03Y	US BENCHMARK 3 YEAR DS GOVT. INDEX	INT	US
UKECBSP	UK £ TO EURO (ECB)	EXCH	UK
USECBSP	US $ TO EURO (ECB)	EXCH	US
FRBRYLD	FRANCE BENCHMARK BOND 10 YR (DS)	INT	FRANCE
ESBRYLD	SPAIN BENCHMARK BOND 10 YR (DS)	INT	SPAIN
ITLTST	ITALY TERM SPREAD (10 YR - 3 MTHS)	SPRE	ITALY
ITMTST	ITALY TERM SPREAD (12 MTHS - 3 MTHS)	SPRE	ITALY
ITLTMT	ITALY TERM SPREAD (10 YR - 12 MTHS)	SPRE	ITALY
BDLTST	GERMANY TERM SPREAD (10 YR - 3 MTHS)	SPRE	GERMANY
BDMTST	GERMANY TERM SPREAD (12 MTHS - 3 MTHS)	SPRE	GERMANY
BDLTMT	GERMANY TERM SPREAD (10 YR - 12 MTHS)	SPRE	GERMANY
USLTST	US TERM SPREAD (10 YR - 3 MTHS)	SPRE	US
USMTST	US TERM SPREAD (12 MTHS - 3 MTHS)	SPRE	US
USLTMT	US TERM SPREAD (10 YR - 12 MTHS)	SPRE	US
UKLTST	UK TERM SPREAD (10 YR - 3 MTHS)	SPRE	UK
BDRVNCARP	NEW PASSENGER CAR REGISTRATIONS	DEM	GERMANY
BDRETTOTF	RETAIL SALES EXCLUDING CARS (BDRETTO3F FOR 2003=100)	DEM	GERMANY
BGACECARP	NEW PASSENGER CAR REGISTRATIONS	DEM	BELGIUM
ESCAR...O	REGISTRATIONS: PASSENGER CAR	DEM	SPAIN
FRCARREGO	NEW CAR REGISTRATIONS (CAL ADJ)	DEM	FRANCE
FRHCONMFD	HOUSEHOLD CONSUMPTION - MANUFACTURED GOODS	DEM	FRANCE
FRHCONMGD	HOUSEHOLD CONSUMPTION - ENGINEERED PRODUCTS	DEM	FRANCE
FRHCONDGD	HOUSEHOLD CONSUMPTION - DURABLE GOODS	DEM	FRANCE
ITCAR...P	NEW PASSENGER CAR REGISTRATIONS	DEM	ITALY
BDWHSALEE	WHOLESALE TRADE TURNOVER, NOMINAL (BV 4.1) (CAL ADJ)	DEM	GERMANY
BDVACTOTO	VACANCIES (DEC 1999 ONWARDS NEW DEFINITION)	EMP	GERMANY
ESEPR548P	EMPLOYMENT PROMOTION CONTRACTS: IN PRACTICE	EMP	SPAIN
FRESUNUPQ	UNEMPLOYMENT: TOTAL - ¡25 YEARS% ACTIVE POP	EMP	FRANCE
ESVACTOTP	JOB VACANCIES $METHODOLOGY BREAK FROM MAY 2005!	EMP	SPAIN
BDOCC011	REAL EFFECTIVE EXCHANGE RATES - CPI BASED	EXCH	GERMANY
EKIPTOT.G	INDUSTRIAL PRODUCTION EXCLUDING CONSTRUCTION (EA19) (WDA)	IP	EMU
USOL2000Q	CLI[b] - AMPLITUDE ADJUSTED	LEA	US
ESOL2000Q	CLI - AMPLITUDE ADJUSTED	LEA	SPAIN
ITOL2000Q	CLI - AMPLITUDE ADJUSTED	LEA	ITALY
EJOL2000Q	CLI - AMPLITUDE ADJUSTED	LEA	EMU 13 COUNTRIES
FROL2000Q	CLI - AMPLITUDE ADJUSTED	LEA	FRANCE
BDOL2000Q	CLI - AMPLITUDE ADJUSTED	LEA	GERMANY
BDM3C...B	MONEY SUPPLY - M3 (CONTINUOUS SERIES)	MON	GERMANY
BDM2C...B	MONEY SUPPLY - M2 (CONTINUOUS SERIES) (PAN BD FROM 1991)	MON	GERMANY

[a] Datastream.

[b] Composite leading indicators by OECD.

Table 5: Dataset of the new €-coin (cont.)

MNEMONICS	TITLE	BLOCK	COUNTRY
FRM1....A	MONEY SUPPLY - M1 (NATIONAL CONTRIBUTION TO M1)	MON	FRANCE
FRM3....A	MONEY SUPPLY - M3 (NATIONAL CONTRIBUTION TO M3)	MON	FRANCE
ITM1....A	MONEY SUPPLY: M1 - ITALIAN CONTRIBUTION TO THE EURO AREA	MON	ITALY
ITM3....A	MONEY SUPPLY: M3 - ITALIAN CONTRIBUTION TO THE EURO AREA	MON	ITALY
EMECBM1.B	MONEY SUPPLY: M1 (EP)	MON	EMU
EMECBM3.B	MONEY SUPPLY: M3 (EP)	MON	EMU
BDPROPRCF	PPI: INDUSTRIAL PRODUCTS, TOTAL, SOLD ON THE DOMESTIC MARKET	PI	GERMANY
BDESY6ERF	PPI: INDUSTRY (EXCEPT CONSTRUCTION, SRWG, WM&R ACTV), 2015=100	PI	GERMANY
ITPROPRCF	PPI	PI	ITALY
ITESDWVTF	PPI: MIG - NON-DURABLE CONSUMER GOODS, 2015=100	PI	ITALY
ITESDIAHF	PPI: MIG - ENERGY, 2015=100	PI	ITALY
ESPPMANUF	PPI - MANUFACTURING INDUSTRY	PI	SPAIN
ESPPDCNSF	PPI - CONSUMER GOODS, DURABLES	PI	SPAIN
ESPPNDCSF	PPI - CONSUMER GOODS, NON-DURABLES	PI	SPAIN
ESPPINVSF	PPI - CAPITAL GOODS	PI	SPAIN
ESPPINTGF	PPI - INTERMEDIATE GOODS	PI	SPAIN
ESPPENRGF	PPI - ENERGY	PI	SPAIN
BGPROPRCF	PPI - INDUSTRY (EXCLUDING CONSTRUCTION)	PI	BELGIUM
EKPROPRCF	PPI: INDUSTRY (EXCLUDING CONSTRUCTION) (EA19)	PI	EMU
EKCONPRCF	HICP - ALL ITEMS (EA19)	PI	EMU
FNPPMAN.F	PPI - MANUFACTURING	PI	FINLAND
BDIFOBUSQ	TRADE & IND: BUS SIT, INDEX, SA	SUR	GERMANY
BDIFOMTAQ	MFG: BUS SIT, INDEX	SUR	GERMANY
BDIFOBDOQ	CNSTR IND: BUS SITUATION, INDEX	SUR	GERMANY
FRSURPMPQ	SURVEY: MANUFACTURING OUTPUT - RECENT OUTPUT TREND	SUR	FRANCE
FRCNFBUSQ	SURVEY: MANUFACTURING OUTPUT LEVEL - GENERAL OUTLOOK	SUR	FRANCE
EKEUSESIG	ECONOMIC SENTIMENT INDICATOR (EA)	SUR	EMU
PMIMANUFEU	PMI MANUFACTURING RECONSTR	SUR	EMU
BDPMIS..Q	MARKIT PMI: SERVICES - BUSINESS ACTIVITY	PMIS	GERMANY
EMPMIS..Q	MARKIT PMI: SERVICES - BUSINESS ACTIVITY	PMIS	EMU
ESPMIS..Q	MARKIT PMI: SERVICES - BUSINESS ACTIVITY	PMIS	SPAIN
FRPMIS..Q	MARKIT PMI SERVICES - BUSINESS ACTIVITY	PMIS	FRANCE
ITPMIS..Q	MARKIT PMI: SERVICES - BUSINESS ACTIVITY	PMIS	ITALY
BGIMPGDSA	IMPORTS (CIF)	TRA	BELGIUM
NLIMPGDSA	IMPORTS - CIF (METHOBREAK JAN 2008)	TRA	NL
BGEXPGDSA	EXPORTS (FOB)	TRA	BELGIUM
FREXPGDSB	EXPORTS FOB	TRA	FRANCE
ESEXPGDSB	EXPORTS	TRA	SPAIN
ESIMPGDSB	IMPORTS	TRA	SPAIN
ITOLC007H	WEEKLY EARN: MFG	WAG	ITALY
BGRETTOTF	TURNOVER OF RETAIL TRADE : TOTAL	DEM	BELGIUM
BDESDWVTF	PPI: MIG - NON-DURABLE CONSUMER GOODS, 2015=100	PI	GERMANY
BDESDIAHF	PPI: MIG - ENERGY, 2015=100	PI	GERMANY
FRESJ72FF	PPI: MIG - INTERMEDIATE GOODS, 2015=100	PI	FRANCE
BGPPIENGF	PPI - ENERGY: ELECTRICITY, GAS, STEAM AND AIR CONDITIONING	PI	BELGIUM
BGPPIINTF	PPI - INTERMEDIATE GOODS	PI	BELGIUM
BGPPICONF	PPI - CONSUMER GOODS	PI	BELGIUM
BGPPIINVF	PPI - INVESTMENT GOODS	PI	BELGIUM
NLESJ72FF	PPI: MIG - INTERMEDIATE GOODS, 2015=100	PI	NL
NLPROPRCF	PPI - MANUFACTURED PRODUCTS	PI	NL
FNPROPRCF	PPI	PI	FINLAND
BDEU3001A	IMPORTS OF GERMANY (CIF)	TRA	GERMANY
BDEU2001A	EXPORTS OF GERMANY (FOB)	TRA	GERMANY
BDI..RELF	REAL EFFECTIVE FX RATE (REER) BASED ON UNIT LABOUR COSTS	WAG	GERMANY