Cycle Extraction: Should the Hamilton Regression Filter be Preferred to the Hodrick-Prescott Filter?

**Keywords:** Detrending, smoothing, spurious cycles, business cycles.

1. **Introduction**

The recent work of [1] has renewed the criticism that the Hodrick-Prescott (HP) filter induces spurious cycles, suffers from end-of-sample bias and relies on an ad-hoc smoothing parameter. As an alternative, he proposes a regression filter (HR) which supposedly solves some of those drawbacks.

In this study, we assess the possible impact of the HR filter if used instead of the HP filter in the OECD system of Composite Leading Indicators (CLIs).

The OECD system of CLIs extensively uses the HP filter with the ultimate goal of anticipating turning points in economic activities and, on a monthly basis, to inform policymakers on possible directions the growth cycle is likely to follow in the near future. In such a framework, it is crucial to provide policymakers with timely, clear and most of all stable information on the state of the cycle. Therefore, any alternative approach to the one currently in place has to guarantee an equally timely and stable detection of turning points, as well as the same, if not better, stability of results in the sample.

To this end, we compare the relative performance of the two filters in full sample and in quasi-real time. With the full sample analysis we aim at assessing whether the HP filter artificially identifies extra cycles as compared to the HR filter. With the quasi real-time approach we evaluate whether, as time goes by and new data points become available, the chronology of TPs identified by each filter remains stable; whether endpoint development of the growth cycle is consistent across the output of the two filters; and whether this development is stable when additional data become available.

Following the order with which the CLIs are developed, for the time being we focus on the chronology of turning points and the end-of-sample direction of Gross Domestic Product (GDP), as it represents the reference series of the System of CLIs. Results from this variable could potentially be extended to all leading indicators.

Hamilton’s paper has attracted quite a lot of attention among practitioners, particularly among central banks in the context of estimating the credit-gap. Our general findings are consistent with the results of [2] [3].

1. **methodology and data**

We compare growth cycles obtained using both the HP and the HR filters by analysing turning points and directions at the end of the sample.

**Turning points**

We looked at the number, location and stability of turning points produced by each filter for each country.

The comparison of the number of turning points serves as a simple assessment of whether spurious cycles occur. With this, the conjecture is that the HR filter produces fewer turning points than the HP.

Next, we investigate whether the different location of turning points identified by the two filters occur in a systemic way. That is, we check whether the location of HR turning points systematically lead, coincide or lag those of the HP filter (discarding those occurring more than 9 months away), following [4]. Furthermore, we check the degree of cyclical synchronization using the concordance index (CI) as proposed by [5] and [6].

With quasi-real time analysis, we evaluate the evolution of the number of turning points and the accuracy of their location. As time goes by and new data points are added at the end of the sample, the location of TP identified by the Bry-Boschan algorithm [7] may fluctuate, disappear, or newly emerge. The accuracy of the TPs location can therefore be measured by the standard deviation of the location of the TPs. A high standard deviation means the TP is not robust against revisions, while a lower one is. Disappearance of a TP is also taken into account through directly counting TPs in each revision.

**Directions at the end of the sample**

Next is the consistency of end-points direction. A base assessment is first done by comparing, between the two filters, the sign of the growth rate of the last three observations[[1]](#footnote-1) using the quasi-real time approach.

We then evaluate the accuracy of the end-points direction by analysing the revision of growth rates of the last three end-points across three subsequent vintages. To this end, a scoring system is introduced to flag large revisions. For each country and filter, a score between 0 and 1 is produced to denote the average degree of end-point changes. A score of 1 indicates that all growth rates of the last three endpoints are perfectly preserved in the two subsequent revisions, and a score of 0 denotes all endpoints growth rates had been revised.

**Data**

Our analysis covers 33 OECD and BRIICS (excluding China) countries. We use seasonally adjusted, real quarterly GDP with samples spanning as early as 1960Q01 (depending on data availability) to 2018Q2. All series are available online in the OECD Main Economic Indicators.

As the OECD CLIs is a system of monthly indicators, before extracting the growth cycle, quarterly GDP estimates are disaggregated into monthly series (through linear interpolation) and outlier are removed using the TRAMO routine [8].

Subsequently, growth cycles are extracted with a double application of the HP filter, first to eliminate the trend and then the erratic component (with =13.93 and =133107.94). A similar strategy is employed to single out the growth cycle with the Hamilton filter. The trend is removed with the regression filter (with *h* = 24 and *p* = 12), and the noise is then filtered out with a smoothing-spline [9]. Finally, the Bry-Boschan routine is used to identify turning points[[2]](#footnote-2) (TPs).

1. **Results**

Empirical analysis based on the full sample suggests that series produced by applying the HR or HP filter have a comparable number of turning points and thus cycles. Such result seems to be in contrast with Hamilton’s prediction that series obtained with the HR filter exhibits less or no spurious cycles. In addition, we found that HR series are generally more volatile than those filtered with HP. As such, the timing of the turning points tend to differ, sometimes quite significantly, though we could not find a clear pattern suggesting that TPs of one series systematically lead or lag those from the other. As a result, the phases of expansion and contraction identified by the two filters tend to be quite different.

Figure 1 shows the case for the OECD area as a whole: GDP is filtered by HP (black solid line) and HR (dotted red line). Both series exhibited 21 turning points. However, only two thirds of corresponding turning points are less than 9 months apart. Of particular note is the HR dating for the onset of the Great Recession for the OECD area which occurs 21 months ahead of NBER’s dating for the United States (2007M12). The resulting length of the crisis is considerably longer (40 months ranging from 2006M3 to 2009M6) than that of the HP (18 months from 01-2008 to 06-2009).

In quasi-real time analysis, we find that the number and location of TPs from the HR filter are substantially different from the HP TPs. In Figure 2, we illustrate the case for the OECD area as a whole during the period from January 2000 to September 2018. Each “horizontal” curve represents a turning point, either peak (P) or trough (T), with its stability with respect to revision determined by its straightness. Thus, a straight horizontal line means that once the TP has been identified, it remains identified at the same location for all subsequent vintages. Likewise, a fluctuating curve signals that the TP changes location depending on the vintage. A dotted curve means that the TP comes and goes.

We note two observations. First, the HR series (Figure 2, HR) shows two additional turning points sporadically appearing in vintages released between 2007 and 2008. Second, the chronology of HR turning points tend to fluctuate more, particularly between 2004 and 2005 (see Figure 2 HR).

Of particular importance is the different sequence of onset dates of the Great Recession. The HR filtered series initially identifies 2006M3 as the start of the crisis (2007 vintage). As new data points become available, the starting date is gradually shifted toward 2006M12, and eventually back to 2006M3. Disregarding minor fluctuations, the latter position is since maintained.

Dating the onset of the crisis proved tricky also for the HP filter, though the difficulties seem to be of a different nature. In this case, the onset of the crisis is initially dated 2004M5, then gradually delayed to 2006M04, followed by 2007M2, and eventually settled on 2007M10. A further shift to 2008M1 occurred a few months later and, from that moment on, unmoved.

Finally, the analysis of end-of sample direction suggests that in only one third of the cases considered the two filters pointed to the same directions. Moreover, the analysis of the accuracy of the end-of-sample direction suggests that change of the signal (sign and size of the growth rate) for the last 3 observations across three subsequent quasi-vintages of the HP series is systematically more stable than with HR.

1. **Conclusions**

With a view of delivering timely and accurate forecast of the business cycle turning points to policymakers, the OECD continually reviews and refines its CLI methodology, an integral part of which is cycle extraction done by the Hodrick-Prescott (HP) filter. The criticisms levied at the HP filter are well known and falls along the lines of spurious cycles and end-point bias. [1] proposes a regression filter (HR) which purportedly solves these issues.

We have put it to test to assess the impact of using the HR filter to extract the growth cycle of GDP. Empirical evidence from the full-sample analysis suggests that, in the long run, the HP and HR filters produce series with a similar number of turning points and, hence, cycles. However, the quasi-real time analysis has revealed that the turning points from the HR filter is significantly more unstable in the short run, flagging many false turning points.

Likewise, we found no improvements in end-point direction. Quasi-real time analysis showed that while the end-point directions produced by the two filters differ significantly, those from the HP filter are revised less upon adding new observations.

These practical considerations make the HR filter undesirable in outputting consistent and reliable signals for policy purposes, though the case on how to circumvent the drawbacks of the HP filter remains open.

# REFERENCES

|  |  |
| --- | --- |
| [1] | J. D. Hamilton, "Why You Should Never Use the Hodrick-Prescott Filter," *The Review of Economics and Statistics,* p. REST\_a\_00706, 2017. |
| [2] | Y. S. Schüler, "On the cyclical properties of Hamilton's regression filter," *Discussion Papers,* 2018. |
| [3] | M. Drehmann and J. Yetman, "Why you should use the Hodrick-Prescott filter - at least to generate credit gaps," 2018. |
| [4] | F. Canova, "Does Detrending Matter For the Determination of the Reference Cycle and the Selection of Turning Points?," *The Economic Journal,* vol. 109, no. 452, pp. 126-150, 1999. |
| [5] | D. Harding and A. Pagan, "Dissecting the cycle: a methodological investigation," *Journal of Monetary Economics,* vol. 49, no. 2, pp. 365-381, 2002. |
| [6] | D. Harding and A. Pagan, "Synchronization of cycles," *Journal of Econometrics,* vol. 132, no. 1, pp. 59-79, 2006. |
| [7] | G. Bry and C. Boschan, "Cyclical Analysis of Time Series: Selected Procedures and Computer Programs," 1971. |
| [8] | G. Gyomai, N. Ahmad and R. Astolfi, "The OECD System of Composite Leading Indicators," in *Handbook on cyclical composite indicators for business cycle analysis*, European Commission, 2017. |
| [9] | P. J. Green and B. W. Silverman, Nonparametric regression and generalized linear models : a roughness penalty approach, Chapman & Hall, 1994, p. 182. |
| [10] | V. Vaccara and B. Zarnowitz, “How good are the leading indicators?,” in *Proceedings of the Business and Economic Statistics Section, American Statistics Association, pp. 41-51,*, Washington, D.C., 1977. |

1. To predict the turning points in real time, dating routines are replaced by simple decision rules such as, for example, the 'three consecutive decline' rule proposed by [10]. [↑](#footnote-ref-1)
2. We use a simplified version of the routine in that outlier are preliminary eliminated using TRAMO. Minimum phase length is to 9 months while the minimum cycle is 24 months. [↑](#footnote-ref-2)