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EMPIRICAL PERFORMANCE OF POTENTIAL GDP AND OUTPUT GAP ESTIMATION METHODS: A CRITICAL REVIEW WITH EVIDENCE FROM EMERGING AND ADVANCED ECONOMIES

Mukhammedova Azizakhon Ikromjon qizi
PhD Candidate in Econometrics and Statistics
Westminster International University in Tashkent
ORCID: 0009-0001-6786-9507

Abstract. Potential GDP and the output gap are estimated using methods ranging from univariate filters to Bayesian unobserved-components (UC) models; however, these approaches are often treated as interchangeable in empirical research and policy analysis. This study critically reviews twelve peer-reviewed studies that apply and compare these methods using real-world data from advanced economies (the United States and the euro area) and emerging markets (Turkey and Israel). The analysis examines the extent to which the methods converge or diverge in estimating the amplitude, cyclical turning points, and revision behaviour of the output gap, as well as the underlying reasons for these differences. The strongest agreement is observed in identifying the timing of major cyclical turning points, whereas the greatest discrepancies arise in the estimated amplitude and persistence of the output gap. Three methodological factors account for most of these differences: the assumed signal-to-noise ratio of the cyclical component; whether the trend specification permits structural breaks or time-varying growth; and the choice of auxiliary variables used to identify the trend-cycle decomposition. Although the evidence from emerging markets is limited to two country cases, it indicates that these divergences become more pronounced in economies characterised by higher volatility and ongoing structural change, highlighting the need for further research extending multivariate and Bayesian approaches to developing countries. The review concludes with practical recommendations for researchers and policymakers regarding the selection, interpretation, and reporting of output gap estimates.

Keywords: output gap; potential GDP; Hodrick–Prescott filter; Kalman filter; unobserved-components model; Beveridge–Nelson filter; production function approach; emerging markets.

Аннотация. Потенциальный ВВП и разрыв выпуска оцениваются с использованием широкого спектра методов — от одномерных фильтров до байесовских моделей ненаблюдаемых компонент (UC). Однако на практике и в прикладных исследованиях эти подходы нередко рассматриваются как взаимозаменяемые. Представлен критический обзор двенадцати рецензируемых исследований, в которых указанные методы применяются и сопоставляются на реальных данных по развитым экономикам (США и зона евро) и странам с формирующимся рынком (Турция и Израиль). Основное внимание уделено тому, в какой степени методы совпадают или расходятся в оценках амплитуды, поворотных точек и последующих пересмотров разрыва выпуска, а также причинам этих различий. Наибольшее совпадение наблюдается при определении времени основных циклических поворотных точек, тогда как наиболее существенные расхождения относятся к оценкам амплитуды и устойчивости разрыва выпуска. Большая часть различий обусловлена тремя методологическими факторами: предполагаемым отношением сигнал/шум циклической компоненты; возможностью учёта структурных сдвигов или переменного темпа роста в тренде; а также выбором вспомогательных переменных, используемых при разделении тренда и цикла. Несмотря на то, что данные по странам с формирующимся рынком ограничиваются двумя примерами, результаты свидетельствуют об усилении указанных расхождений в более волатильных экономиках, находящихся в процессе структурных изменений, что подчёркивает необходимость дальнейшего развития многомерных и байесовских методов применительно к развивающимся странам. Обзор завершается практическими рекомендациями для исследователей и разработчиков экономической политики по выбору, интерпретации и представлению оценок разрыва выпуска.

Ключевые слова: разрыв выпуска; потенциальный ВВП; фильтр Ходрика–Прескотта; фильтр Калмана; модель ненаблюдаемых компонент; фильтр Бевериджа–Нельсона; подход производственной функции; страны с формирующимся рынком.

INTRODUCTION

Potential GDP and the output gap—the percentage deviation of actual output from its sustainable, non-inflationary level—are central inputs to monetary policy rules, structural fiscal balance calculations, and assessments of an economy's medium-term slack. Because potential output is unobservable, it must be inferred from observed data using statistical or structural models. A large and continuously expanding body of literature has proposed alternative estimation methods, including univariate detrending filters such as the Hodrick–Prescott (HP) filter, Kalman filter and unobserved-components (UC) state-space models, the Beveridge–Nelson (BN) decomposition, multivariate and structural VAR-augmented filters, and the production function approach (PFA), which estimates potential output on the basis of trend labour, capital, and total factor productivity.

These methods may produce substantially different results, and such differences extend beyond the distinction between real-time and final-vintage estimates. Orphanides and van Norden (2002) demonstrated that output gap estimates are frequently revised as new data become available. A complementary strand of the literature examines this issue of real-time reliability directly; however, it falls outside the scope of the present review. Instead, the analysis addresses a more focused question: among empirical studies that apply and compare estimation methods using a largely fixed data vintage, where do the resulting output gap estimates converge or diverge in terms of magnitude, timing, and revision behaviour, and which methodological choices account for these differences?

This question is important for two principal audiences. Applied researchers can better understand which modelling choices, rather than the nominal choice of filtering technique, account for differences in reported output gap estimates, thereby enabling methodological decisions to be based on analytical justification rather than established convention. Policymakers who rely on a single headline estimate of the output gap can also gain a clearer understanding of the extent to which that estimate depends on assumptions that are often not explicitly discussed in non-technical policy documents, such as the implicit signal-to-noise ratio of a filter or the treatment of structural breaks in trend growth. This consideration is particularly important for developing and emerging economies, where output series are generally shorter, more volatile, and more frequently affected by structural change than those of advanced economies. Consequently, accurate estimation of the output gap plays an especially important role in supporting inflation-targeting frameworks and the design of fiscal rules.

Two of the twelve studies reviewed in this paper—Ozbek and Ozlale (2005) for Turkey and Scacciavillani and Swagel (2002) for Israel—provide direct evidence from emerging-market economies. Throughout the review, these studies serve as reference cases for assessing whether conclusions derived primarily from evidence for the United States and the euro area remain applicable when output dynamics are characterised by greater volatility and less stable long-term trends. The remaining ten studies, focusing on the United States and the euro area, establish the principal methodological benchmark against which the findings from the emerging-market cases are evaluated.

LITERATURE REVIEW

The HP filter remains the most widely used univariate detrending method in applied macroeconomics owing to its simplicity and minimal data requirements. However, several of the studies reviewed here indicate that its underlying assumptions are relatively restrictive. A fixed smoothing parameter and the implicit assumption of serially independent cyclical innovations may lead the filter to misrepresent both the amplitude and the smoothness of the business cycle. Grant and Chan (2017a) demonstrate this formally by showing that the HP filter can be recovered as a special case of a more general correlated unobserved-components (UC) model, and that relaxing the assumption of an independent cyclical component yields a model with a comparable fit but a materially different estimated cycle amplitude. Ozbek and Ozlale (2005) reach a related conclusion from the perspective of an emerging-market economy. Applied to Turkey, a volatile and structurally evolving economy, conventional filtering methods tend to generate an overly smooth trend, thereby understating the actual amplitude of the cycle and reducing the filter's ability to distinguish major crisis episodes.

A larger group of studies employs Kalman-filter-based UC models, which decompose output into stochastic trend and cyclical components estimated jointly using maximum-likelihood or Bayesian methods. These models generally accommodate volatility and structural change more flexibly than fixed-parameter filters. Ozbek and Ozlale (2005) extend the standard Kalman filter by allowing time-varying parameters estimated through the extended Kalman filter and show that this specification captures Turkey's major crisis episodes more effectively than a fixed-parameter alternative. For Italy, Zizza (2006) compares univariate and multivariate structural time-series models and finds that, although GDP alone produces a relatively modest cyclical amplitude, the univariate and multivariate specifications are broadly consistent with one another. Proietti, Musso, and Westermann (2007)

apply both bivariate UC models and a multivariate production function approach to the euro area, evaluating random-walk, integrated random-walk, and damped-slope trend specifications according to the criteria of validity, reliability, and consistency. Their results indicate that the damped-slope specification performs best. Chen and Mills (2012) extend the multivariate framework further by incorporating five variables linked through a phase-shift mechanism and use the resulting model to characterise the lead-lag relationships between the output gap and the cycles in inflation, unemployment, industrial production, and investment. Grant and Chan (2017b) adopt a formal Bayesian model-comparison framework for the United States, computing marginal likelihoods using an improved cross-entropy method across eight competing UC specifications. Their findings indicate that the data favour correlated-innovation models and, during certain periods, models incorporating a structural break in trend growth over the orthogonal-innovation specification implicit in the HP filter. González-Astudillo (2019a, 2019b) extends the UC framework in a cross-sectional direction by using heterogeneity across U.S. states and euro-area countries, respectively, to improve aggregate output gap estimation. González-Astudillo and Roberts (2022) further demonstrate that the choice of auxiliary variable—whether unemployment, inflation, or gross domestic income—materially influences which bivariate UC decomposition of U.S. GDP is assessed as the most reliable.

Kamber, Morley, and Wong (2018) revisit the Beveridge–Nelson decomposition and show that its conventional implementation implies an unrealistically high signal-to-noise ratio, resulting in a relatively small and erratic output gap that differs from widely accepted views regarding business-cycle amplitude and persistence. By imposing a lower signal-to-noise ratio, they obtain a larger and more persistent output gap that exhibits economically intuitive cyclical behaviour, is less susceptible to revision, and provides more accurate forecasts of output growth and inflation than several competing decompositions.

Another strand of the literature favours combining filters rather than selecting a single method. Gosselin and Lalonde (2006) propose an eclectic approach for the United States that combines an extended multivariate filter with a structural VAR-implied equilibrium path. This approach relies on data series that are less prone to revision and on a clearly specified economic framework to minimise output gap estimation error rather than merely maximise in-sample fit.

Finally, the production function approach estimates potential output using trend labour input, capital stock, and total factor productivity rather than relying solely on the behaviour of output. Proietti, Musso, and Westermann (2007) implement a multivariate, model-based production function approach for the euro area alongside their UC models, enabling a direct within-study comparison of the two methodological traditions. Scacciavillani and Swagel (2002) apply both the production function approach and statistical filtering methods to Israel, a small and historically volatile economy, and find that purely statistical filters are particularly sensitive to end-of-sample revisions in such an environment. In contrast, the production function approach anchors potential output more explicitly to observable factor inputs, albeit at the cost of requiring additional assumptions regarding trend factor shares and factor utilisation. Considered together with the evidence for Turkey reported by Ozbek and Ozlale (2005), these findings suggest that the practical implications of methodological assumptions—whether related to a filter's smoothing parameter or the factor-share assumptions embedded in the production function approach—vary across countries and tend to become more pronounced in smaller and more volatile economies.

RESEARCH METHODOLOGY

Studies were identified through targeted database and citation-based searches using search strings that combined the terms “*output gap*” or “*potential GDP*” with method-specific keywords, including “*HP filter*,” “*Hodrick–Prescott*,” “*Kalman filter*,” “*state-space model*,” “*unobserved components*,” “*multivariate filter*,” and “*production function*.” Studies were retained for full-text screening only if they met the following criteria: they were published in a Scopus- or Web of Science-indexed journal; they applied one or more estimation methods to real-world macroeconomic data rather than presenting a purely theoretical or simulation-based contribution; and their principal contribution was the application or comparison of estimation methods rather than a cross-country comparison, an examination of the output gap–inflation relationship, or an assessment of real-time revision behaviour, each of which falls outside the scope of the present review. Twelve studies meeting these criteria, published between 2002–2022 and covering the United States, the euro area, Turkey, and Israel, constitute the evidence base for this review.

For each of the twelve selected studies, the following information was extracted: the country or region analysed and its classification as either an advanced or an emerging economy; the estimation method or methods applied and compared; the sample period; the reported magnitude, turning points, and persistence of the estimated output gap; any explicit discussion of revision behaviour or estimation reliability; and, where provided, the authors' explanation of why their estimates differed from those obtained using alternative methods. This information provides the basis for the comparative tables.

ANALYSIS AND RESULTS

Table 1 summarises the twelve reviewed studies by country or region, method, data span, and key empirical finding.

Table 1. Comparative Summary of Empirical Studies on Potential GDP and Output Gap Estimation Methods

Study	Country/ Region	Method(s)	Data span	Key empirical finding
Ozbek & Ozlale (2005)	Turkey (emerging market)	Extended Kalman filter (time-varying parameters) vs. standard Kalman filter	1988–2003	The extended filter avoids the excessively smooth trend produced by standard filters on volatile emerging-market data, correctly identifying the 1994 and 2001 financial crises.
Gosselin & Lalonde (2006)	United States	“Eclectic approach” combining a multivariate filter and SVAR	1961–2004 (approx.)	Combining a multivariate filter with an SVAR-implied equilibrium path reduces reliance on any single filter and lowers revision risk relative to a standalone filter.
Proietti, Musso & Westermann (2007)	Euro area	Bivariate unobserved-components (UC) model and multivariate production function approach (PFA)	1970s–2004 (approx.)	A damped-slope trend specification fits the data better than random-walk or IRW trends; validity, reliability, and consistency criteria jointly favour the multivariate PFA over simple univariate filters.
Chen & Mills (2012)	Euro area	Five-variate UC model with trigonometric cycle and phase-shift terms	1970–2006 (approx.)	The output gap leads the inflation and unemployment cycles by approximately one year and lags industrial production by approximately one quarter; overall revision variance ranges from approximately 0.50–0.95, depending on the sub-sample and model order.
Zizza (2006)	Italy	Univariate and multivariate structural time-series (UC) models	1970–2003 (approx.)	GDP cycle amplitude ranges from approximately 0.12–0.31 percent of trend (cycle length: 3–5 years); industrial production is considerably more cyclical, at approximately 0.6–0.9 percent. Univariate and multivariate specifications provide reciprocally consistent estimates.
Grant & Chan (2017a)	United States	New correlated UC model with a second-order Markov trend, nesting the HP filter as a special case	Post-war U.S. GDP	Differences between HP-filter and correlated-UC output gap estimates are primarily attributable to the specification of the stochastic trend; relaxing the HP filter’s implicit assumption of serially independent cycles yields a model with a fit comparable to that of the standard correlated UC model.
Grant & Chan (2017b)	United States	Bayesian model comparison across eight univariate and bivariate UC specifications using cross-entropy marginal-likelihood estimation	Post-war U.S. GDP	Formal Bayes factor comparison shows that the data favour specifications with correlated trend-cycle innovations and, in some periods, a break in trend growth over the orthogonal-innovation UC model implicit in the HP filter.
Kamber, Morley & Wong (2018)	United States	Beveridge–Nelson (BN) filter with a restricted, lower signal-to-noise ratio	Post-war U.S. GDP	Imposing a lower signal-to-noise ratio on the BN decomposition yields a large, persistent output gap that behaves intuitively over the business cycle, is subject to smaller revisions, and forecasts output growth and inflation better than several alternative decompositions.

González-Astudillo (2019a)	United States	Bayesian UC model exploiting cross-sectional state-level output and unemployment data	State panel, various vintages	Incorporating state-level heterogeneity sharpens the national output gap estimate relative to the conventional single-equation national aggregate approach.
González-Astudillo (2019b)	Euro area	Bayesian UC model exploiting country-level heterogeneity in GDP, unemployment, and inflation	Pre-2007 to 2018Q3	Output is estimated at approximately 4 percent above potential before the 2007–2008 financial crisis, near potential by mid-2009, approximately 2.5 percent above potential in 2011, approximately –3 percent by the end of 2013 during the sovereign debt crisis, and approximately 3.5 percent above potential by 2018Q3.
González-Astudillo & Roberts (2022)	United States	Comparison of bivariate UC models pairing GDP with unemployment, inflation, or gross domestic income	Post-war U.S. GDP	The choice of auxiliary variable materially changes which trend-cycle decomposition is judged to be the most reliable; no single auxiliary series dominates across all reliability criteria.
Scacciavillani & Swagel (2002)	Israel (small, emerging-market-adjacent economy)	Production function approach vs. statistical (HP-type) filters	1970s–1990s (approx.)	For a small, volatile, structurally changing economy, purely statistical filters are especially sensitive to end-of-sample revisions, whereas the production function approach links potential output more explicitly to observable factor inputs, although it requires additional auxiliary assumptions.

Where methods agree

Agreement is strongest in the timing of major cyclical turning points. Ozbek and Ozlale's (2005) extended Kalman filter accurately identifies Turkey's 1994 and 2001 financial crises. González-Astudillo's (2019b) Bayesian UC model for the euro area identifies the period preceding the 2007–2008 financial crisis, the return to potential by 2009, the renewed expansion in 2011, and the sovereign debt crisis trough in 2013, consistent with the broader macroeconomic history of the period. This pattern is observed in both the advanced-economy and the emerging-market cases reviewed here, suggesting that the estimation methods share sufficient common information—primarily reflected in the behaviour of output growth—to identify periods during which an economy was expanding or contracting relative to potential, even though they differ substantially in the estimated magnitude of the output gap.

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Where methods disagree, and why

Agreement is considerably weaker with respect to the amplitude and persistence of the estimated output gap, as well as the magnitude of revisions when new data become available. **Table 2** organises the principal sources of this divergence identified across the reviewed studies.

Table 2. Sources of Divergence in Output Gap Estimates Across Estimation Methods

Source of divergence	How it changes the estimate	Illustrative studies
Signal-to-noise ratio / prior on cycle variance	A high, freely estimated ratio gives a small, noisy, weakly persistent gap; a low, imposed ratio gives a large, smooth, persistent gap.	Kamber, Morley & Wong (2018); Grant & Chan (2017a, 2017b)
Trend specification (random walk vs. IRW vs. damped slope vs. breaks)	A more flexible trend reallocates variance from cycle to trend, shrinking the estimated gap relative to a fixed-drift random walk.	Proietti, Musso & Westermann (2007); Grant & Chan (2017b)
Univariate vs. multivariate information set	Adding auxiliary series disciplines the trend-cycle split and typically lowers revision variance, but the choice of variable is not neutral.	Chen & Mills (2012); Gosselin & Lalonde (2006); González-Astudillo & Roberts (2022)
Cross-sectional/regional heterogeneity	Exploiting sub-national or member-state heterogeneity can sharpen aggregate estimates.	González-Astudillo (2019a, 2019b)
Statistical filter vs. production function approach	Filters use output and auxiliary series alone; the PFA builds potential output from factor inputs, changing level and volatility of the gap.	Scacciavillani & Swagel (1999); Proietti, Musso & Westermann (2007)
Sample length and structural volatility	Short, volatile, structurally changing series make it harder to separate trend from cycle without over-smoothing or over-fitting.	Ozbek & Ozlale (2005)

The most consequential source of divergence is the signal-to-noise ratio that is either implicit in or imposed on the cyclical component. Kamber, Morley, and Wong (2018) demonstrate this clearly: the same Beveridge–Nelson decomposition can produce either a small, erratic output gap or a large, persistent one, depending on whether the signal-to-noise ratio is freely estimated or constrained to a lower value. Grant and Chan (2017a, 2017b) reach a structurally similar conclusion within the unobserved-components framework. The HP filter's implicit assumption of serially independent cyclical innovations, rather than differences in the underlying data, explains a substantial share of the differences between HP-filter and UC-model output gap estimates.

A second source of divergence is the treatment of trend growth. Proietti, Musso, and Westermann (2007) find that a damped-slope trend specification outperforms both a simple random walk and an integrated random walk for the euro area. Grant and Chan (2017b) find that formal Bayesian model comparison sometimes favours specifications with one or two discrete breaks in trend growth over a smoothly evolving trend. Since any variance not attributed to the trend is, by construction, attributed to the cycle, more flexible trend specifications tend to produce smaller estimated output gaps than rigid, fixed-drift trends.

A third source of divergence concerns the information set used. Multivariate approaches that incorporate auxiliary variables, such as inflation and unemployment in Proietti, Musso, and Westermann (2007); inflation, unemployment, industrial production, and investment in Chen and Mills (2012); or state- and country-level panels in González-Astudillo (2019a, 2019b), generally report smaller revision variances than univariate filters. This finding is consistent with the eclectic multivariate-filter approach proposed by Gosselin and Lalonde (2006). González-Astudillo and Roberts (2022) add an important caveat, however: the choice of auxiliary variable is not neutral, since pairing GDP with unemployment, inflation, or gross domestic income may each be identified as the most reliable specification depending on the evaluation criterion. Thus, incorporating auxiliary information improves the estimation process without eliminating model-selection uncertainty.

Finally, the production function approach differs from purely statistical filters in terms of both interpretative content and estimated magnitude. Because the PFA explicitly links potential output to trend factor inputs, it can attribute a given output gap to specific sources, such as an unusually low capital utilisation rate rather than a generic cyclical shock, a distinction of practical relevance for policy communication that purely statistical filters cannot provide. Scacciavillani and Swagel (2002) note that this advantage comes at the cost of greater sensitivity to auxiliary assumptions regarding trend factor shares, a consideration that becomes more important in small, structurally volatile economies such as Israel in their sample.

Implications for developing and emerging economies

Only two of the twelve studies reviewed here—Ozbek and Ozlale (2005) on Turkey and Scacciavillani and Swagel (2002) on Israel—provide direct evidence from emerging-market or small open economies. This reflects a limitation of the present review rather than suggesting that the broader literature is silent on developing countries. Within this limited evidence, however, a consistent pattern emerges: the three sources of

methodological divergence identified in Table 2 appear to be more pronounced in volatile, structurally changing economies than in the advanced-economy cases reviewed here. Ozbek and Ozlale (2005) show explicitly that a fixed-parameter filter over-smooths Turkey's trend, a limitation that is addressed by a time-varying-parameter Kalman filter. Scacciavillani and Swagel (2002) show that statistical filters applied to Israel are particularly sensitive to end-of-sample revisions. Both findings suggest that the choice of signal-to-noise ratio and trend flexibility, identified above as the principal sources of divergence in advanced-economy studies, is likely to become even more important when output series are shorter, more volatile, and subject to more frequent structural breaks, as is typical of many developing economies. Extending the multivariate and Bayesian model-comparison methods that perform well in the U.S. and euro-area evidence reviewed here to a broader range of developing countries, where such methods remain comparatively underutilised, therefore represents one of the most promising directions for future empirical research emerging from this review.

Practical implications

For applied researchers, reporting a single output gap estimate without disclosing the underlying signal-to-noise ratio, trend specification, and information set is likely to understate the uncertainty surrounding the estimate. Presenting a limited range of estimates based on plausible alternative specifications, as several of the reviewed studies do, is preferable to reporting a single point estimate as if it were uncontested. This recommendation is particularly relevant for developing-country settings, where uncertainty is likely to be greatest precisely where the policy implications are most significant. For policymakers, the consistency of turning-point identification across estimation methods provides reassurance for qualitative business-cycle assessment. However, the considerable variation in estimated output gap amplitudes suggests that caution should be exercised when placing substantial weight on the precise numerical value of any single reported output gap estimate.

CONCLUSION AND SUGGESTIONS

This review examined twelve empirical studies that apply and compare methods for estimating potential GDP and the output gap, drawing on evidence from the United States, the euro area, Turkey, and Israel. The central finding is that these methods demonstrate considerably greater agreement on whether an economy is operating above or below potential than on the magnitude of the output gap. Three methodological factors—the assumed signal-to-noise ratio of the cyclical component, the degree of flexibility permitted in trend growth, and the scope and selection of auxiliary information—account for most of the differences in output gap amplitude, persistence, and revision behaviour documented across the reviewed studies. Overall, multivariate and formally Bayesian model-comparison approaches generally perform better than simple univariate filters, including the standard HP filter, with respect to reliability and predictive validity. Nevertheless, no single estimation method consistently outperforms all others across every evaluation criterion and empirical setting.

The limited emerging-market evidence included in this review, based on studies of Turkey and Israel, suggests that these methodological differences become more pronounced in economies characterised by greater volatility and more frequent structural change, where accurate output gap estimation is particularly important for the design of monetary and fiscal policies. These findings indicate a clear direction for future research: extending the multivariate and Bayesian approaches that perform well in advanced-economy applications to a broader and systematically compiled sample of developing countries, while examining whether the three principal sources of divergence identified in this review become more significant as structural volatility increases. The scope of this review is intentionally focused. Accordingly, studies whose primary contribution is a cross-country comparison, an examination of the relationship between the output gap and inflation, or an assessment of real-time revision behaviour were excluded from the analysis. Each of these topics represents an important area for future research and warrants dedicated investigation.

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