Petra Gerlach

petra.gerlach@bis.org

The global output gap: measurement issues and regional disparities[1]

The global output gap seems to be negative but closing. According to structural estimates, the gap is still wide, particularly in the advanced economies. However, these measures may overestimate potential output, eg by not accounting for the fact that certain investments may have turned out to be unproductive. Purely statistical estimates, on the other hand, suggest that the global output gap has already closed in both the advanced and the emerging market economies, but statistical measures are subject to an end-point problem that too often makes them signal a closed gap at the current edge.

JEL Classification: E32.

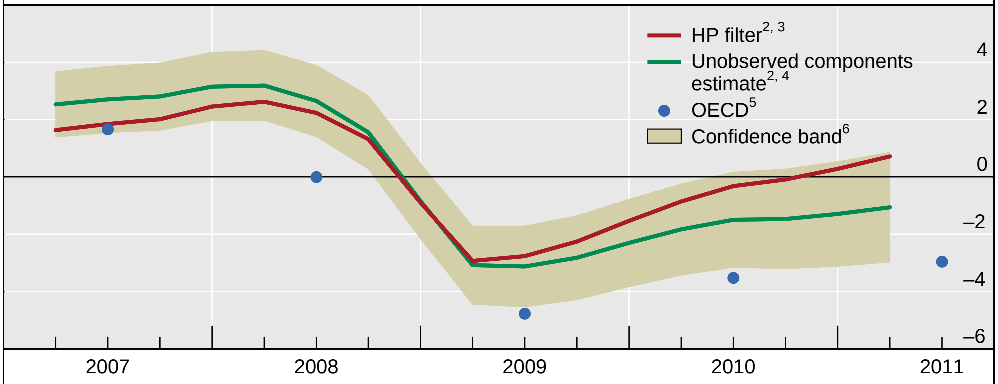
Introduction

Is the global economy back on track? Some measures of the global output gap, especially those that capture the state of the business cycle, suggest that it is. Graph 1 shows the different estimates reached using different measures. The global output gap computed from country data published by the OECD indicates that there is still considerable slack in the economy; the OECD also forecasts a negative output gap for 2011. By contrast, the widely used Hodrick-Prescott (HP) filter suggests a slightly positive gap. An unobservable components (UC) model lies between the two but exhibits large uncertainty.

This special feature tries to explain why different approaches lead to such divergent estimates of how much slack there is in the global economy at the current juncture. The range of measures available, and the different results they yield, are illustrated using data from the euro area and the United States. In this analysis, the crucial question is the degree to which the crisis has affected potential output, and we discuss the difficulties involved in attempting to assess potential at turning points of the business cycle. We also review aggregation issues and regional disparities. The article concludes with a discussion of possible interpretations of current estimates of the global output gap.

[1] I thank Bilyana Bogdanova and Gert Schnabel for excellent research assistance and Piet Clement for his help on the history of the term "output gap".

Global output gap[1]



[1] Weighted average based on 2005 PPP-converted GDP weights of Argentina, Australia, Brazil, Canada, China, Chinese Taipei, the Czech Republic, Denmark, the euro area, Hong Kong SAR, Hungary, India, Indonesia, Japan, Korea, Malaysia, Mexico, New Zealand, Norway, Peru, Poland, Singapore, South Africa, Sweden, Switzerland, Thailand, Turkey, the United Kingdom and the United States. [2] First quarter of 2011 partly estimated using forecasts for GDP growth from JPMorgan Chase. [3] Based on a world aggregate; trend calculated using Hodrick-Prescott filter with standard specification. [4] Based on a world aggregate; using unobserved components. For details, see the appendix. [5] Aggregation of national output gaps as calculated by the OECD; forecast for 2011. Includes Australia, Canada, the Czech Republic, Denmark, the euro area, Hungary, Japan, Mexico, New Zealand, Norway, Poland, Sweden, Switzerland, the United Kingdom and the United States. [6] 95% confidence band computed from the unobserved components estimates.

Sources: OECD, *Economic Outlook*; JPMorgan Chase; national data; BIS estimates. Graph 1

What exactly is the output gap and how can we measure it?

In 1962 Arthur Okun published an article on what would later be called Okun's law. His idea was to link the unemployment rate to a measure of the shortfall of actual GNP from potential income, the "GNP gap". Okun emphasised that this potential was not the maximum output an economy could achieve but, rather, the output which could be realised without giving rise to inflationary pressure (Congdon (2008)).

The term potential output had already been in use for some time before Okun wrote his article. *The Economist* reported in 1911 that

> [i]n the North of England […] there is still a potential output, a legacy of the last boom, far in advance of the demand, in certain kinds of work.

That said, it took more than 50 years, and the appearance of Okun's paper, before *The Economist* used the term output gap for the first time, in 1964.

Output gaps are widely used …

Central banks have been looking at measures of the output gap for a long time as one of many information variables in the policy process. In 1993, John B Taylor showed that the Federal Reserve's interest rate setting was well described by a simple rule in which changes in the federal funds rate target are related to movements in inflation relative to an inflation objective and in the output gap (Taylor (1993)). While central banks' interest rate setting relies, of course, on a much wider set of data and is in no way mechanical, the Taylor rule has been widely used by academics and market participants alike.[2] The popularity of the Taylor rule has ensured that estimates of the output gap, and thus of potential output, are in high demand.

... but not clearly defined

Potential output represents different things to different economists. Classically oriented scholars use the term in Okun's sense, where potential is the sustainable level of output that an economy could achieve in the absence of shocks. By contrast, proponents of modern macroeconomic models that rely on microeconomic foundations (so-called dynamic stochastic general equilibrium (DSGE) models) define potential output as the output the economy would produce in the absence of nominal frictions.[3] Such frictions include price and wage stickiness – ie the fact that prices and salaries are not adjusted from day to day. Thus the output gap in DSGE models does not capture the business cycle but rather the effect of nominal rigidities.[4]

In what follows we concentrate on output gap estimates that attempt to measure the business cycle. We review two broad approaches, one statistical, the other structural. As an illustration, we present output gap measures for the euro area and the United States, two economies for which data are readily available.

Statistical approaches

Statistical measures compute the gap mostly from actual GDP

Statistical approaches to measuring the output gap try to derive potential output from actual output (real GDP). One immediate stumbling block is that initial releases of GDP data often need to be corrected. As a consequence, real-time statistical estimates of the output gap are often revised.

The most widely used statistical measure of the output gap is the HP filter, which models (the logarithm of) potential output essentially as a weighted average of a straight line and actual (log) GDP. (The appendix presents computational details.) There are a number of other statistical filters. For instance, band-pass filters remove short-term and very long-term fluctuations from actual GDP to identify the business cycle component of output. And UC models treat both potential output and the output gap as latent variables for which nothing is known but some time series properties. They typically assume that potential grows over time, at a rate that may vary, while the output gap is mean reverting. Of course, such underlying assumptions determine, to a large extent, the estimates reached.[5]

---

[2] Also, many central banks compute Taylor rates as one of many cross-checks in their policy decision-making process.

[3] The real business cycle model – the predecessor of DSGE models – assumes no nominal frictions. As a consequence, actual output always equals potential output in this class of model.

[4] In fact, potential output can vary with the business cycle in DSGE models, for instance if consumers' preferences adjust to shocks (Mishkin (2007)). Not surprisingly, standard statistical measures of the output gap, which assume no such variation, do not perform well in estimated DSGE models (Neiss and Nelson (2005)).

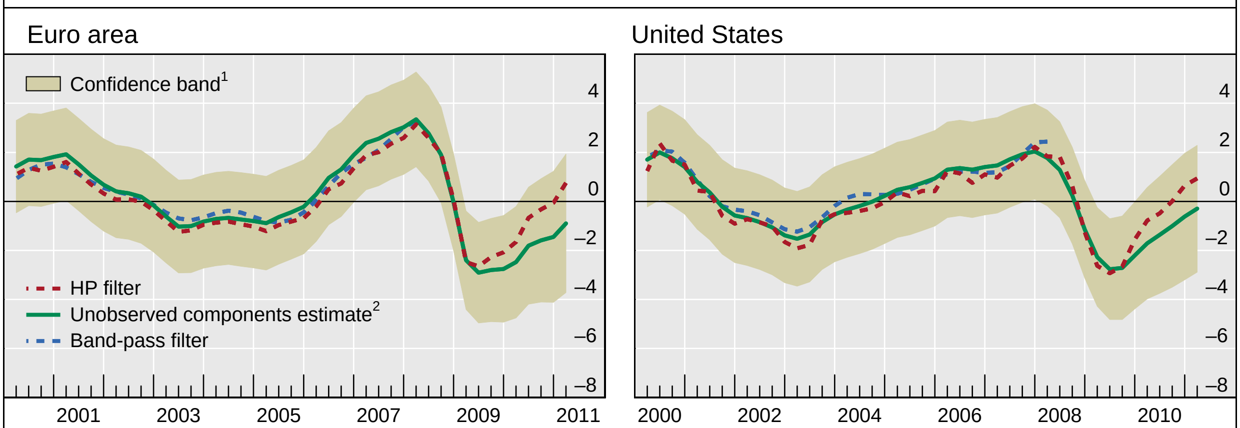
[5] UC models can also include other data, such as inflation and unemployment, to estimate the output gap.

Graph 2 shows statistical output gap estimates for the euro area and the United States. A 95% confidence band constructed from the UC estimate spans over 5 percentage points at the current edge in both economies and illustrates the large uncertainty surrounding output gap estimates. While the UC gap is negative in both the euro area and the United States, the HP gap is slightly positive. This runs counter to other indicators of activity and is probably due to an end-point problem.

Real-time HP estimates too often signal a closed output gap. To compute potential output and the output gap for some point *t* in the past, the HP filter uses data from before and after time *t*. This approach ensures that a temporary drop in the growth rate of actual GDP at time *t* is identified as a period with essentially unaffected potential GDP growth and a negative output gap. For a real-time estimate of the output gap, with no future data available, the HP filter becomes one-sided and looks only at data up to time *t*. It then mechanically attributes part of the drop in actual growth to a decline in potential growth. Intuitively, the HP filter treats the latest data point as the "new normal" and yields an output gap estimate close to zero.[6]

End-point problems are especially severe at turning points of the business cycle. The red line in Graph 3 shows the HP estimate of the US output gap using today's data.[7] The green line is computed using the same data, but omitting any observations after time *t* in arriving at the estimate for time *t*. Thus, the first observation is computed using data up to the first quarter of 1976; the second point adds the observation for the second quarter of that year; and so on. The deviation between the two lines captures the effect of the

Statistical measures



[1] 95% confidence band computed from the unobserved components estimates. [2] For details, see the appendix.

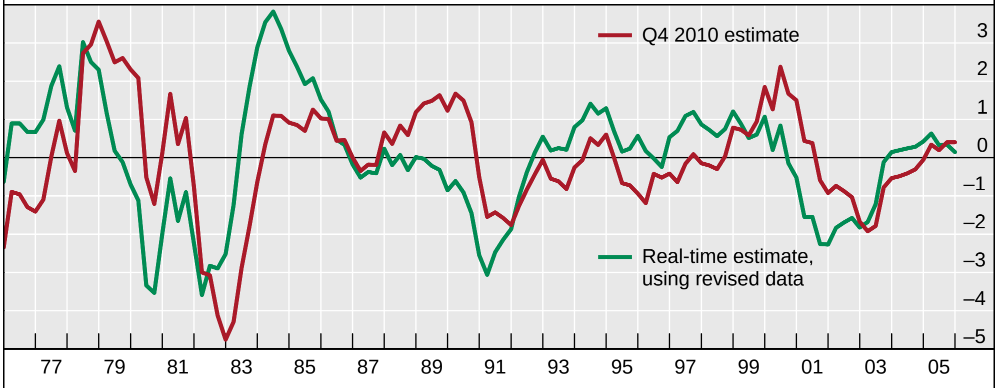
Sources: National data; BIS estimates. Graph 2

---

[6] In principle, the end-point problem can be alleviated by forecasting future GDP values, thus allowing for a reversion of potential output to its long-term trend, and then applying the filter.

[7] We show output gap estimates up to 2005 since the end-point problem becomes visible only ex post. Note that this is not a genuine real-time estimate since it ignores the impact of data revisions. This impact can be large, but estimates using proper real-time data from the Federal Reserve Bank of Philadelphia (not shown in the graph) indicate that data revisions are not correlated with the business cycle. On data revisions, see Orphanides and van Norden (2002).

End-point problems in the HP measure of the US output gap



[1] Real-time estimates use data only up to time *t* and thus exhibit the end-point problem. All output gaps computed using data from 1959 onwards.

Sources: Federal Reserve Bank of Philadelphia real-time data bank; BIS estimates. Graph 3

end-point problem and is particularly large at turning points of the business cycle. At the current juncture, the HP filter may therefore exaggerate the extent to which the global economy has recovered from the crisis.

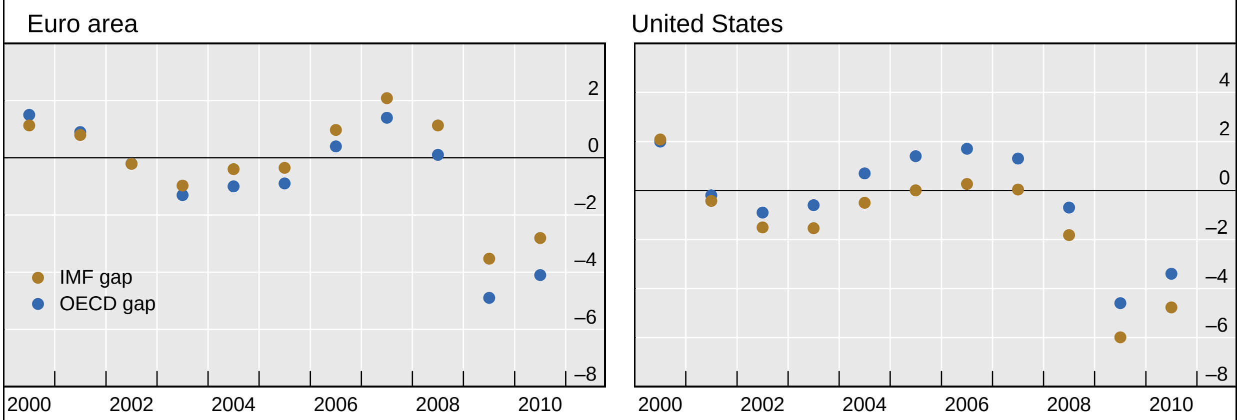
Structural approaches

Structural measures use mostly capital and labour data

Structural approaches make assumptions about how much output, in principle, a certain combination of capital and labour in the economy could produce. This solves the end-point problem inherent in statistical approaches, although, of course, data revisions continue to matter. Structural estimates of potential output rely on a particular production function (often a Cobb-Douglas production function) and require a quantification of the technological knowledge in the economy (total factor productivity). Structural measures often also make use of information from other variables related to the business cycle, such as unemployment and inflation, which the Phillips curve suggests respond to the output gap. The advantage of a production function approach is that it is based on data that are not mechanically linked to actual GDP – a bottom-up approach.

Current structural estimates from the IMF and the OECD signal a large negative output gap for the euro area and the United States (Graph 4). This suggests that the structural models have not corrected potential output downwards as much as the purely statistical estimation methods have.

Of course, the crisis may not have affected potential output much. Yet one can also think of structural reasons why it might have (see also OECD (2010)). For instance, productive capital may be smaller than measured because capital equipment in some sectors (eg in construction) has become superfluous, and higher capital costs may reduce investment and thus cause capital to depreciate faster. The contribution of labour may have decreased because certain labour skills have become less useful. Total factor productivity, finally, Structural measures



Sources: IMF, *World Economic Outlook*; OECD, *Economic Outlook*. Graph 4

might be decreasing if there has been less investment in research and development.[8]

Identifying and quantifying changes in the structure of the economy takes time. Thus, while statistical measures may suggest changes in potential output at the current edge too fast, structural models may do so too slowly. There are apparently no real-time datasets of production function estimates of the output gap. However, one can track how structural output gap estimates have changed over time in central bank reports. One interesting example is the measurement of the Swedish output gap after the Nordic financial crisis in the early 1990s. In 1996, the Riksbank estimated a production function output gap of –6% for 1993. By 2011, this trough had been revised upwards, to –5%. It seems plausible that this correction is due to a downward revision of the structural estimate of potential output.[9] Hence, it is possible that structural measures today exaggerate potential output and paint too gloomy a picture of the output gap.

Has the global output gap closed?

The analysis above illustrates that measuring the output gap is difficult even when extensive data are available. Data problems render the estimation of output gaps even more complicated for emerging market economies and, by extension, for the world as a whole. Survey data are scarce, and estimating structural models is fraught with uncertainties. How to assess labour supply, for instance, in countries with a large potential labour pool in rural areas? To some extent, statistical estimates such as the HP filter may be preferable in such situations, since they capture past GDP dynamics without taking a stance on the underlying trends in capital, labour and technology.

---

[8] On the other hand, efficiency may have increased due to the streamlining of processes in response to the crisis.

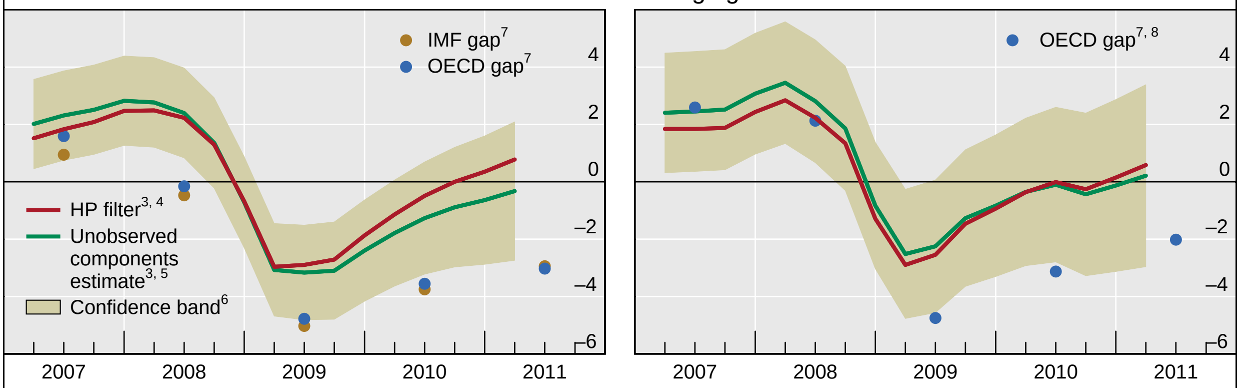
[9] See Riksbank (1996) and (2011). Of course, central banks keep improving their economic models, which also can lead to revisions of structural output gap estimates. It is noteworthy that the HP estimate already suggested a gap of about –4.5% in 1996, and still does so today.

Aggregation of national data is not straightforward

The process of aggregating national data can add to the uncertainty of global output gap estimates. One issue is whether one should first aggregate national data and then compute the global output gap, or first compute national output gaps and then aggregate them to obtain a global figure. A second issue is whether to use market exchange rates or PPP-adjusted rates in converting national GDP data to US dollar figures. Conversion using purchasing power parity corrects for different costs of living across countries and is advisable if the goal is a comparison of the standard of living. Converting the data using actual exchange rates reflects countries' purchasing power in the global economy, so that emerging market economies get a relatively small weight in the aggregation. For the purpose of constructing a global output gap, there is no clearly superior aggregation method. Fortunately, it turns out that aggregation-related differences are negligible at the current juncture.[10]

A final caveat in interpreting the global output gap is that aggregation may mask regional disparities. Recent press commentary has emphasised the risk of economic overheating in emerging markets and contrasted this with the slow recovery in the major advanced economies.[11] To evaluate how much dispersion there is in the current economic recovery, it is useful to look separately at output gap estimates for the advanced and the emerging market economies (Graph 5). Somewhat surprisingly, the HP output gaps are slightly

Regional output gaps



All aggregations using 2005 PPP-converted GDP weights.

[1] Australia, Canada, Denmark, the euro area, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom and the United States. [2] Argentina, Brazil, China, Chinese Taipei, the Czech Republic, Hong Kong SAR, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Peru, Poland, Singapore, South Africa, Thailand and Turkey. [3] First quarter of 2011 partly estimated using forecasts for GDP growth from JPMorgan Chase. [4] Based on a country group aggregate; trend calculated using HP filter with standard specification. [5] Based on a country group aggregate; using unobserved components. For details, see the appendix. [6] 95% confidence band computed from the unobserved components estimates. [7] Aggregation of national output gaps as calculated by the IMF and the OECD; forecasts for 2011. [8] The Czech Republic, Hungary, Mexico and Poland.

Sources: IMF, *World Economic Outlook*; OECD, *Economic Outlook*; JPMorgan Chase; national data; BIS estimates Graph 5

[10] Both procedures yield an HP filter-based global output gap of 0.7% This result obtains under both market and PPP exchange rates. For the global output gap computed from OECD data, the market rate based gap is –3.5%, slightly below the PPP-converted estimate of –3.0%, which is the one shown in Graph 1.

[11] Chapter II of BIS (2011) discusses the recent dispersion in real output growth across economies.

positive for both groups, indicating an evenly spread recovery. Again, this seems to reflect, in part, an end-point problem, with the HP filter treating the latest data point as the new normal. The structural output gap computed from OECD data is large and negative for the advanced economies, as is an output gap measure calculated using structural estimates from the IMF. The OECD-calculated gap is also negative for the emerging market economies, but the latter has been closing somewhat faster than that of the advanced economies. However, the fact that structural estimates of potential output adjust slowly to sectoral changes may exaggerate the size of the current gap.

In sum, both statistical and structural output gap estimates measure the business cycle accurately only long after the fact. For policy purposes, it is important to look at a broad range of measures and to be aware of the shortcomings of the different approaches. Today, the overall message of the different measures is that the global output gap is negative but closing.

References

Bank for International Settlements (2011): *81st Annual Report*, June (forthcoming).

Congdon, T (2008): “Two concepts of the output gap”, *World Economics*, vol 9, no 1, pp 147–75.

Mishkin, F (2007): “Estimating potential output”, speech delivered at the Conference on Price Measurement for Monetary Policy, sponsored by the Federal Reserve Bank of Dallas, Dallas, Texas, 24 May, www.federalreserve.gov.

Neiss, K and E Nelson (2005): “Inflation dynamics, marginal cost, and the output gap: evidence from three countries”, *Journal of Money, Credit and Banking*, vol 37, no 6, pp 1019–45.

Organisation for Economic Cooperation and Development (2010): *Economic Outlook*, vol 2010, no 87, May.

Orphanides, A and S van Norden (2002): “The unreliability of output-gap estimates in real time”, *Review of Economics and Statistics*, vol 84, no 4, pp 569–83.

Sveriges Riksbank (1996): *Inflation Report*, no 3, September.

——— (2011): *Monetary Policy Update*, April.

Taylor, J (1993): “Discretion versus policy rules in practice”, *Carnegie-Rochester Conference Series on Public Policy,* vol 39, pp 195–214.

Appendix
Details on statistical filters

The Hodrick-Prescott filter identifies as (log) potential output the series y_t^{pot} that minimises

$$\sum_{t=1}^{T}(y_t - y_t^{pot})^2 + \lambda\sum_{t=2}^{T-1}(\Delta y_{t+1}^{pot} - \Delta y_t^{pot})^2 ,$$

with y_t the logarithm of real GDP and λ the smoothing parameter. This parameter indicates how important the goal of obtaining a constant growth rate of potential is relative to the goal of having potential output not deviating much from actual. The graphs in this feature use the standard smoothing parameter for quarterly data of 1600. The output gap is given by $y_t - y_t^{pot}$.

The band-pass filter removes high- and low-frequency movements from y_t to obtain a series gap_t that shows variations at business cycle frequency, which for quarterly data is normally set as a range of 6 to 32 quarters. Technically, this is achieved by computing a moving average with leads and lags, of which typically 12 of each are included for quarterly data. Thus,

$$gap_t = \sum_{j=0}^{12} w_j y_{t-j} + \sum_{j=0}^{12} w_j y_{t+j} ,$$

with w_j predefined weights. The inclusion of leads means that there is no band-pass estimate available for the last 12 quarters, which explains the early end of the blue line in Graph 2.

The unobserved components estimates presented in the text are obtained from a state space model where

$$y_t = y_t^{pot} + gap_t ,$$
$$y_t^{pot} = \mu_t + y_{t-1}^{pot} + e_t^y ,$$
$$\mu_t = \mu_{t-1} + e_t^{\mu}$$

and

$$gap_t = c_0 + c_1 gap_{t-1} + c_2 gap_{t-2} + e_t^{gap} ,$$

with μ_t the time-varying growth rate of potential and the e_t s independently and normally distributed innovations.