Estimating finance-neutral output gaps

Extended Abstract

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1 Introduction

The decomposition of GDP into a long-run trend and a short-run cyclical component has a long tradition in the empirical macroeconomic literature. A commonly used approach is to combine output with information contained in the rate of inflation via a Phillips curve. The resulting trend is then defined as the inflation-neutral level of output, typically referred to as *potential output*. The deviation of actual output from its potential is an important variable for the conduct of economic policy as it provides an estimate of the cyclical position of the economy. A positive output gap goes hand in hand with inflationary pressure signaling that demand exceeds supply.

Since the onset of the 2007-2008 financial crisis and the ensuing Great Recession, the traditional approach of identifying potential output via a Phillips curve has been challenged, though. As inflation remained surprisingly low and stable during the past decade and a half, there was no signal that pointed either to a positive pre-crisis output gap or to a negative post-crisis gap. Still, GDP in countries such as the U.S. and Spain had been growing on an unsustainable path prior to the financial crisis, boosted by the buildup of financial imbalances in credit and property markets, and subsequently output decreased sharply as the financial bubble burst.

Several channels may have contributed to the transmission of the buildup and bust of financial imbalances to GDP. Notably, according to the 'financial accelerator' mechanism, during a financial boom, an increased amount of lending can fuel demand for housing and other assets, driving up their prices and increasing both households' and firms' collateral, encouraging banks to extend further credit for the financing of additional housing and non-housing consumption and investment (Aoki et al., 2004; Bernanke et al., 1999; Iacoviello, 2005). In turn, the corresponding debt becomes a forcing variable when high imbalances build up and the bubble bursts, as households and firms cut their expenditures in order to repair their balance sheets (Borio, 2014, p.187).

Initiated by Borio (2014), the academic literature has started to augment the traditional approach to estimate potential output and the corresponding output gap by adding financial variables. The resulting trend measure is referred to as finance-neutral or *sustainable output* and goes beyond the idea of an inflation-neutral level of output. By removing the unsustainable part of GDP that is driven by financial imbalances, the sustainable output measure evolves more steadily during financial crisis periods compared to traditional potential output measures. Therefore, the corresponding sustainable

output gaps tend to suggest more severe overheating (i.e., a larger positive output gap) before the crisis and more excess capacity afterwards (a more negative gap) compared to traditional output gap measures (see Berger et al., 2015, p.7). Moreover, the real-time sustainable output gap estimates are expected to be less prone to ex-post revisions, compared to the traditional output gap estimates, which would enable policymakers to better assess the structural balance in real time.

The global character of the 2007-2008 crisis has also uncovered the strong connection of financial markets across countries. While the empirical literature has well documented commonalities of business cycles across countries (Kose et al., 2003, 2012; Berger and Richter, 2017), intensive research on the synchronization of financial variables has increased only in recent years showing that financial variables indeed share common dynamics across countries (Breitung and Eickmeier, 2014; Miranda-Agrippino and Rey, 2015; Cerutti et al., 2017; Ha et al., 2017).

The goal of this paper is to provide a measure of the output gap and hence the cyclical position of a country by considering the fact that financial variables as well as international cycles can help to pin down a country's business cycle. To this end, we construct an empirical framework which allows us to separate the cyclical component in GDP for a large number of countries according to different sources. First of all, by including financial variables into the output gap estimation, we acknowledge the fact that financial markets affect the business cycle, potentially creating large imbalances and putting the overall macroeconomic stability at risk. The resulting output gap can differ considerably in the presence of large financial imbalances as compared to traditional approaches. Second, we are able to separate a country's output gap into international and country-specific cycles and calculate their relative importance with respect to the size of the output gap. The distinction between international versus domestic drivers for a country's business cycle is important to inform policymakers in order to choose the right tools for stabilizing the economy.

2 A model for sustainable output

Let $y_{i,t}^j$ denote a vector of macro and financial variables in country j. Each variable in $y_{i,t}^j$ is decomposed in a variable-specific trend $\mu_{i,t}^j$, two common world cycles, labeled the world business cycle $\psi_{BC,t}^W$ and the world financial cycle $\psi_{FC,t}^W$, and two country-specific cycles, labeled the domestic business cycle $\psi_{BC,t}^j$ and the domestic financial cycle $\psi_{FC,t}^j$

$$y_{i,t}^j = \mu_{i,t}^j + \alpha_i^j \psi_{BC,t}^W + \beta_i^j \psi_{FC,t}^W + \gamma_i^j \psi_{BC,t}^j + \delta_i^j \psi_{FC,t}^j + \varepsilon_{i,t}^j, \qquad \varepsilon_{i,t}^j \overset{iid}{\sim} \mathcal{N}(0, \sigma_{\varepsilon,i,j}^2), \tag{1}$$

$$\mu_{i,t+1}^j = \mu_{i,t}^j + \nu_{i,t}^j + \zeta_{i,t}^{\mu,j}, \qquad \zeta_{i,t}^{\mu,j} \overset{iid}{\sim} \mathcal{N}(0, \sigma_{\zeta,\mu,i,j}^2), \tag{2}$$

$$\nu_{i,t+1}^j = \nu_{i,t}^j + \zeta_{i,t}^{\nu,j}, \qquad \zeta_{i,t}^{\nu,j} \overset{iid}{\sim} \mathcal{N}(0, \sigma_{\zeta,\nu,i,j}^2), \tag{3}$$

for $i = 1, \ldots, k$ variables and $j = 1, \ldots, C$ countries. All cycles follow AR(2) processes

$$\psi_{BC,t}^W = \rho_{1,11}^W \psi_{BC,t-1}^W + \rho_{2,11}^W \psi_{BC,t-2}^W + \eta_{BC,t}^W \tag{4}$$

$$\psi_{FC,t}^W = \rho_{1,22}^W \psi_{FC,t-1}^W + \rho_{2,22}^W \psi_{FC,t-2}^W + \eta_{FC,t}^W \tag{5}$$

$$\psi_{BC,t}^j = \rho_{1,11}^j \psi_{BC,t-1}^j + \rho_{2,11}^j \psi_{BC,t-2}^j + \eta_{BC,t}^j \tag{6}$$

$$\psi_{FC,t}^j = \rho_{1,22}^j \psi_{FC,t-1}^j + \rho_{2,22}^j \psi_{FC,t-2}^j + \eta_{FC,t}^j \tag{7}$$

with $(\eta_{BC,t}^W, \eta_{FC,t}^W, \eta_{BC,t}^j, \eta_{FC,t}^j) \overset{iid}{\sim} \mathcal{N}(\mathbf{0}, \Sigma_\eta)$. For further use, eqs. (1)-(3) can be written in matrix

notation as

$$y_t = \mu_t + \Lambda\psi_t + \varepsilon_t, \tag{8}$$

with y_t a $(k*C\times 1)$ column vector stacking the k observed variables for all countries C, μ_t a $(k*C\times 1)$ column vector stacking the k unobserved trends for all countries C, Λ a $(k*C\times 2+2*C)$ matrix with factor loadings on the world and country-specific factors, ψ_t a $(2+2*C\times 1)$ column vector stacking the unobserved cycles, and ε_t is an error vector of dimension $(k*C\times 1)$.

2.1 Identification

The factor structure of the model extracts two common international factors and two common domestic factors out of the k variables per country. As such, k can be of any order. The most commonly used variables in the literature to estimate the business cycle re real GDP, inflation, and unemployment. The financial cycle is typically identified using credit, house prices and stock prices. We follow the literature such that the k variables in $y_{i,t}^{j}$ are (in this order): real GDP, inflation, and unemployment as macroeconomic indicators, while credit, house prices, and stock prices are used as financial indicators. By using multiple macroeconomic and financial variables, the uncertainty in identifying the latent business and financial cycles is reduced (see e.g. Basistha and Startz, 2008).

Identification of the multi-level multi-factor model in eq. (8) requires normalizing restrictions on either the factor loadings $\Lambda = (\Lambda_W, \Lambda_C)$, the factors $\psi_t = (\psi_{BC,t}^{W}, \psi_{FC,t}^{W}, \psi_{BC,t}^{C}, \psi_{FC,t}^{C})$, or on both. For $k = 6$ variables per country divided equally among macroeconomic and financial variables, we choose the following normalization.

World factors

1. $\alpha_1^{1,n} = 1$ (GDP of the reference country) and $\beta_4^{1,n} = 1$ (credit of the reference country). These restrictions imply that the scale for the first world factor $\psi_{BC,t}^{W,n}$ is identified by GDP in the reference country, while the scale of the second world factor $\psi_{FC,t}^{W,n}$ is identified by the credit variable in the reference country. The remaining variables in all countries load without restrictions on the two normalized world factors.

2. $\alpha_4^{1,n} = 0$. This restriction implies that the credit variable in the reference country does not load on the first factor $\psi_{BC,t}^{W,n}$.

3. Σ_η^n is a diagonal matrix. This restriction implies that innovations to all factors are orthogonal.

Country factors

Similar restrictions on the factor loadings are applied to identify the country-specific factors.

1. $\gamma_1^{j,n} = 1$ and $\delta_4^{j,n} = 1$ for each country $j = 1, \ldots, C$. The remaining variables in a country load on the normalized country-specific factors without any restrictions on the loadings.

2. $\gamma_4^{j,n} = 0$ for each country $j = 1, \ldots, C$.

Given these normalizations we have that

$$\Lambda^n \psi_t^n = \begin{bmatrix} 1 & \beta_1^{1,n} & 1 & \delta_1^{1,n} & & & & & & \\ \alpha_2^{1,n} & \beta_2^{1,2} & \gamma_2^{1,n} & \delta_2^{1,n} & & & & & & \\ \alpha_3^{1,n} & \beta_3^{1,n} & \gamma_3^{1,n} & \delta_3^{1,n} & & & & & & \\ 0 & 1 & 0 & 1 & & & & & & \\ \alpha_5^{1,n} & \beta_5^{1,n} & \gamma_5^{1,n} & \delta_5^{1,n} & & & & & & \\ \alpha_6^{1,n} & \beta_6^{1,n} & \gamma_6^{1,n} & \delta_6^{1,n} & & & & & & \\ \alpha_1^{2,n} & \beta_1^{2,n} & & & 1 & \delta_1^{2,n} & & & & \\ \alpha_2^{2,n} & \beta_2^{2,n} & & & \gamma_2^{2,n} & \delta_2^{2,n} & & & & \\ \alpha_3^{2,n} & \beta_3^{2,n} & & & \gamma_3^{2,n} & \delta_3^{2,n} & & & & \\ \alpha_4^{2,n} & \beta_4^{2,n} & & & 0 & 1 & & & & \\ \alpha_5^{2,n} & \beta_5^{2,n} & & & \gamma_5^{2,n} & \delta_5^{2,n} & & & & \\ \vdots & \vdots & & & & & \ddots & & & \\ \alpha_1^{C,n} & \beta_1^{C,n} & & & & & & 1 & \delta_1^{C,n} \\ \alpha_2^{C,n} & \beta_2^{C,n} & & & & & & \gamma_2^{C,n} & \delta_2^{C,n} \\ \alpha_3^{C,n} & \beta_3^{C,n} & & & & & & \gamma_3^{C,n} & \delta_3^{C,n} \\ \alpha_4^{C,n} & \beta_4^{C,n} & & & & & & 0 & 1 \\ \alpha_5^{C,n} & \beta_5^{C,n} & & & & & & \gamma_5^{C,n} & \delta_5^{C,n} \\ \alpha_6^{C,n} & \beta_6^{C,n} & & & & & & \gamma_6^{C,n} & \delta_6^{C,n} \end{bmatrix} \begin{bmatrix} \psi_{BC,t}^{W,n} \\ \psi_{FC,t}^{W,n} \\ \psi_{BC,t}^{1,n} \\ \psi_{FC,t}^{1,n} \\ \psi_{BC,t}^{2,n} \\ \psi_{FC,t}^{2,n} \\ \vdots \\ \psi_{BC,t}^{C,n} \\ \psi_{FC,t}^{C,n} \end{bmatrix}, \tag{9}$$

such that

$$\psi_{BC,t}^{W,n} + \beta_1^{1,n} \psi_{FC,t}^{W,n} = \alpha_1^1 \psi_{BC,t}^W + \beta_1^1 \psi_{FC,t}^W \qquad \text{(world cycle in GDP)}, \tag{10}$$

$$\psi_{FC,t}^{W,n} = \alpha_4^1 \psi_{BC,t}^W + \beta_4^1 \psi_{FC,t}^W \qquad \text{(world cycle in credit)}, \tag{11}$$

and for each country $j = 1, \ldots, C$

$$\psi_{BC,t}^{j,n} + \delta_1^{j,n} \psi_{FC,t}^{j,n} = \gamma_1^j \psi_{BC,t}^j + \delta_1^j \psi_{FC,t}^j \qquad \text{(domestic cycle in GDP)}, \tag{12}$$

$$\psi_{FC,t}^{j,n} = \gamma_4^j \psi_{BC,t}^j + \delta_4^j \psi_{FC,t}^j \qquad \text{(domestic cycle in credit)}. \tag{13}$$

Note that we want to identify *sustainable* output and hence the *finance-neutral output gap* by means of financial variables and international cycles rather than to provide a structural identification for real and financial shocks. Therefore, the given normalization implies that (i) the world financial factor $\psi_{FC,t}^{W,n}$ is a 'full' international cycle in the financial variables, i.e. a combination of the international business cycle $\psi_{BC,t}^W$ and the international financial cycle $\psi_{FC,t}^W$; and (ii) the factor $\psi_{BC,t}^{W,n}$ is identified as the the part of the international business cycle which is not correlated with the 'full' international financial cycle.[1] Similarly, country-specific factors $\psi_{FC,t}^{j,n}$ are a combination of country j's business cycle $\psi_{BC,t}^j$ and financial cycle $\psi_{FC,t}^j$, while the factors $\psi_{BC,t}^{j,n}$ are domestic cycles in real variables that are uncorrelated with financial variables. This normalization is sufficient for our research question, but does not allow for a structural interpretation of the shocks.

[1] The factors ψ_t^n are orthogonal.

2.2 Variance shares

For each country $j = 1, \ldots, C$, the *finance-neutral output gap* is then given by the difference between the actual level of GDP and its trend, or *sustainable output*, and can be divided into international and country-specific cycles

$$y^j_{GDP,t} - \mu^j_{GDP,t} = \alpha^{j,n}_{GDP}\psi^{W,n}_{BC,t} + \beta^{j,n}_{GDP}\psi^{W,n}_{FC,t} + \gamma^{j,n}_{GDP}\psi^{j,n}_{BC,t} + \delta^{j,n}_{GDP}\psi^{j,n}_{FC,t} + \varepsilon^j_{GDP,t}. \tag{14}$$

Similarly, we can compute the gap for each variable i.

An interesting exercise is to investigate which part of the transitory variation in each variable is explained by the international cycles relative to the country-specific cycles. To this end, we first compute the unconditional variance of the transitory component in each variable i in country j

$$\begin{aligned}\tau^j_{0,i} &= var(y^j_{i,t} - \mu^j_{i,t}) \\ &= (\alpha^{j,n}_i)^2 var(\psi^{W,n}_{BC,t}) + (\beta^{j,n}_i)^2 var(\psi^{W,n}_{FC,t}) + (\gamma^{j,n}_i)^2 var(\psi^{j,n}_{BC,t}) + (\delta^{j,n}_i)^2 var(\psi^{j,n}_{FC,t}) + \sigma^2_{\varepsilon,i,j}.\end{aligned}$$

The corresponding variance shares for the international factors are

$$VS^{i,j}_{BC^W} = \frac{(\alpha^{j,n}_i)^2 var(\psi^{W,n}_{BC,t})}{\tau^j_{0,i}}, \qquad VS^{i,j}_{FC^W} = \frac{(\beta^{j,n}_i)^2 var(\psi^{W,n}_{FC,t})}{\tau^j_{0,i}},$$

and similarly for the country-specific factors

$$VS^{i,j}_{BC^C} = \frac{(\gamma^{j,n}_i)^2 var(\psi^{j,n}_{BC,t})}{\tau^j_{0,i}}, \qquad VS^{i,j}_{FC^C} = \frac{(\delta^{j,n}_i)^2 var(\psi^{j,n}_{FC,t})}{\tau^j_{0,i}}.$$

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