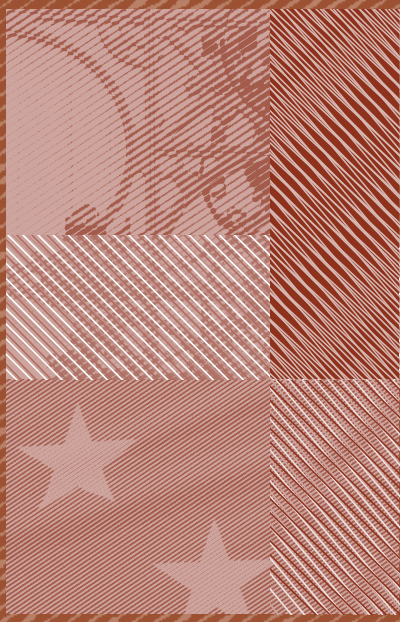
# GROWTH BEYOND IMBALANCES. SUSTAINABLE GROWTH RATES AND OUTPUT GAP REASSESSMENT

2013

Enrique Alberola, Ángel Estrada
and Daniel Santabárbara



**Documentos de Trabajo**
**N.º 1313**

BANCO DE **ESPAÑA**
Eurosistema

# GROWTH BEYOND IMBALANCES.SUSTAINABLE GROWTH RATES AND OUTPUT GAP REASSESSMENT

# GROWTH BEYOND IMBALANCES. SUSTAINABLE GROWTH RATES AND OUTPUT GAP REASSESSMENT(*)

Enrique Alberola, Ángel Estrada(**) and Daniel Santabárbara

BANCO DE ESPAÑA

(*) The views expressed in this paper are those of the authors alone and do not necessarily reflect the views of the Banco de España or its staff.
We would like to acknowledge Gabriel Pérez-Quirós, Philip Hill and the participants in Banco de España and IMF seminars for their valuable comments. All remaining errors are obviously ours.
(**) Corresponding author: E-mail: aestrada@bde.es.

Documentos de Trabajo. N.º 1313
2013

ISSN: 1579-8666 (on line)

**Abstract**

'The Great Recession' was preceded by a prolonged period of high growth accompanied by low and stable inflation, the so called 'Great Moderation'. During that period, potential growth estimates were trending upwards and output gaps remained small. However, other imbalances were progressively accumulating, eventually bringing about the worst crisis in decades. Standard potential growth estimates, which consider inflation as the only indicator of macroeconomic imbalances, along with the stability of inflation in that period, therefore provided misleading signals to policymakers. This paper introduces a methodology to obtain sustainable growth rates, as an alternative measure to potential growth. Sustainable growth is defined as the output growth that does not generate or widen macroeconomic imbalances, identified through a wide set of domestic and external indicators. This allow us to reassess the behavior of output gaps in the US, the UK, Spain, Germany and China both in 'the Great Moderation' period and during 'the Great Recession'. In countries with large imbalances, sustainable growth rates are more stable than potential growth resulting in output gaps that were substantially larger in the period prior to the crisis.

**Keywords:** sustainable growth, macroeconomic imbalances, output gaps, potential growth.

**JEL Classification:** E32, F44, G01.

**Resumen**

La «Gran Recesión» vino precedida por una dilatada fase de alto crecimiento junto con inflación baja y estable, llamada la «Gran Moderación». Durante ese período, las estimaciones del crecimiento potencial eran elevadas y las brechas de producción se mantenían muy moderadas. Sin embargo, se estaban ampliando paulatinamente otros desequilibrios, que finalmente desencadenaron la peor crisis de las últimas décadas. Por tanto, las estimaciones tradicionales de crecimiento potencial, que consideran la inflación como el indicador que resume todos los desequilibrios macroeconómicos, junto con la propia estabilidad de la inflación es este período, proporcionaron información inadecuada a los responsables económicos. Este documento presenta una metodología para estimar la tasa de crecimiento sostenible de una economía, como una alternativa al crecimiento potencial. El crecimiento sostenible se define como aquel que no genera o amplía los desequilibrios macroeconómicos, identificados con un amplio conjunto de indicadores internos y externos. Esto nos permitirá reevaluar la evolución de las brechas de producción de Estados Unidos, Reino Unido, España, Alemania y China, tanto en la etapa de «Gran Moderación» como durante la «Gran Recesión». En países con profundos desequilibrios, el crecimiento sostenible estimado es más estable que el potencial, generando brechas de producción mucho mayores en la fase previa a la crisis.

**Palabras clave:** crecimiento sostenible, desequilibrios macroeconómicos, brecha de producción, crecimiento potencial.

**Códigos JEL:** E32, F44, G01.

## CONTENTS

## 1 Introduction

The global financial crisis of 2008 was preceded by a protracted phase of economic expansion coupled with low inflation and macroeconomic economic stability. This period came to be known as the 'Great Moderation' (see, for example, Stock and Watson, 2002; and Bernanke, 2004) and it was widely considered that the observed growth was underpinned by solid economic foundations. However, during this period domestic and external imbalances, many of them closely related to the exuberance of the financial sector, were accumulating. These eventually brough about the worst crisis in decades, which has become known, in contrast to the previous period, as the 'Great Recession'. To be fair, there were warnings from different quarters that the imbalances building up mean that the observed growth rates were unsustainable. For instance, the IMF alerted to the global imbalances (the build-up of increasing current account deficits and surpluses), the BIS emphasised the risks deriring from asset bubbles and excessive credit growth and, in specific countries, such as Spain, it was recognized ex-ante that the observed current account deficits required quite high long-term growth expectations to be sustainable (Campa and Gavilán, 2006). However, the dominant perception was that the high growth rates were there to stay. The progressive increase in the estimated potential growth rate contributed to - and was a reflection of - this perception.

The concept of potential growth plays a key role in the design of macroeconomic policies. Monetary, fiscal and, more recently, macroprudential policies take into account output gap estimates – the difference between potential and observed output – to adapt their stance in order to reduce possible macroeconomic imbalances and dampen aggregate fluctuations. Indeed, potential growth has been subject to extensive analysis in the theoretical and empirical literature, but the relevance and usefulness of these concepts for economic policy will depend on two factors. First, the ability of the output gap to reflect and summarise the imbalances of the economy. And second, the degree of uncertainty surrounding the estimates of the output gap and their robustness to new information.

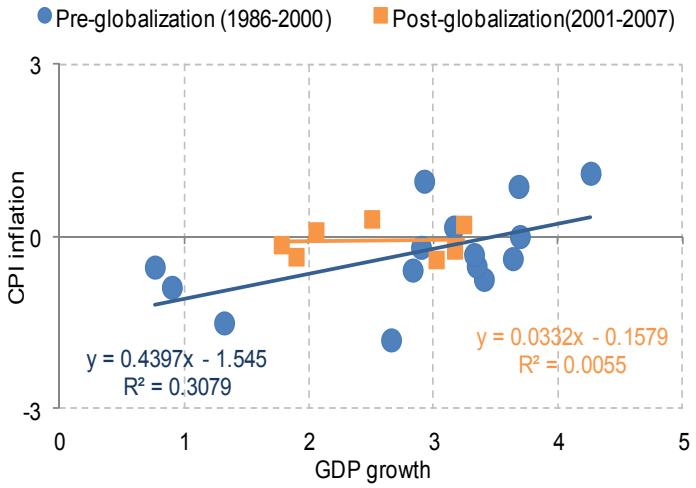
In that respect, the experience of the crisis reveals the weaknesses of standard potential growth estimates as a tool to capture the sustainable rate of growth of the economy. The main limitation of the potential growth estimates is the consideration of just one indicator to sum up the imbalances of the economy: the inflation rate, which is supposed to capture the deviations of observed from structural unemployment. This approach involves the estimation of potential growth through the *Phillips curve*, which allows the NAIRU, that is the "potential" unemployment rate, to be calculated.

However, inflation rates, represented by consumer prices (CPI), seem not to have been a sufficient indicator of the macroeconomic imbalances of the economy during the last decade or so. As can be seen in Figure 1, advanced economies displayed a statistically significant positive correlation between growth and changes in inflation before 2001, as implied by the joint consideration of the Phillips curve and Okun's Law. This association mostly disappeared after 2001. Even though GDP growth showed a certain amount of variability (less than in the period before 2001), inflation remained basically stable. Various reasons have been put forward to explain this result: the success of central banks in controlling inflation, reforms in the labuor and product markets, and the globalisation process, among others.[1] Arguably, 2001 marks the

**1.** See IMF (2013) for an empirical analysis on the lower response of inflation to economic slack in the last decade, i.e., on the reasons behind the flatter Phillips curve.

coming of age of globalisation, as China became a full member of the World Trade Organisation that year; besides, at that time, most of the central banks of developed countries had changed their monetary policy strategies to target inflation.

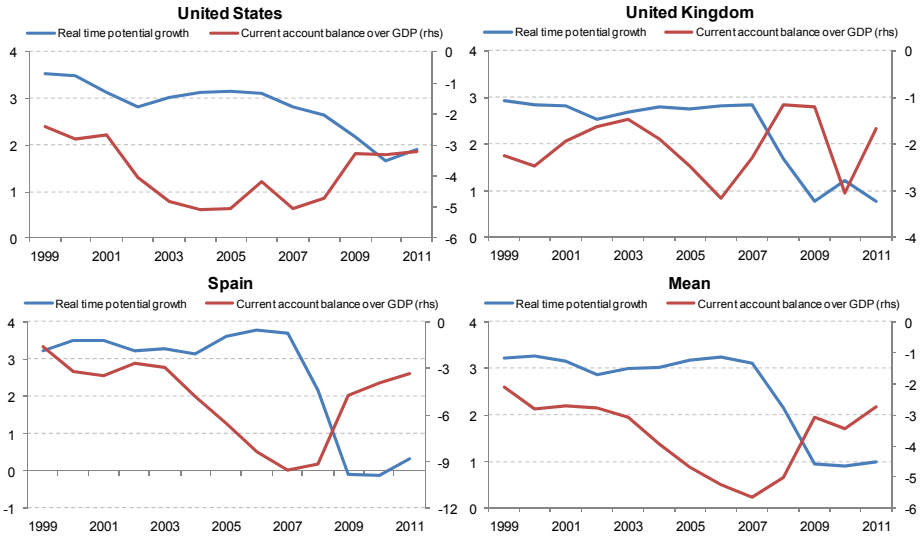
**Figure 1. GDP vs. Inflation. Advanced economies (simple averages)**




Source: IMF (WEO)

At a time when inflation had stabilised, other indicators of imbalances showed a significant widening in many countries. In this respect, the behaviour of the external accounts in certain developed countries, such as the US, the UK and Spain, is especially well known. In that period, their current account deficits increased significantly, while at the same time, potential growth estimates remained quite strong (US, UK) or even increased (see Figure 2). It could be argued that part of the observed growth in these economies was fostered by sizable capital inflows and, as inflation did not react, this was interpreted, at the time, as a permanent improvement in growth. The crisis has shown that observed growth in that period was excessive and its nature pernicious for the stability of the system.

**Figure 2. GDP vs. current account balances. Advanced economies (%)**




Sources: IMF, European Commission and US Congressional Budget Office

This paper presents a methodology to obtain estimates of sustainable growth rates. The sustainable growth rate is defined as the output growth that does not generate or widen macroeconomic imbalances, which are identified through a wide set of domestic and external indicators (for alternative definitions, see, for example, Basu and Fernald, 2009). The methodology is analogous to that used to estimate potential growth, with two major modifications. First, several refinements to the components of production are made in order to obtain a more precise framework to assess cyclical fluctuations related to imbalances. Second, we consider a much richer set of economic and financial variables which may reflect economic imbalances, in order to identify which imbalances drive the business cycle. On the basis of these elements, series of sustainable growth rates for the period 1970-2011 are estimated for five countries, in order to include in our sample both developed and emerging countries with external deficits (US, UK, Spain) and surpluses (Germany and China). As will be seen, this paper has strong links to the literature related to early warning indicators (Frenkel and Saravelos, 2012), which have recently been incorporated into the multilateral supervision mechanisms of the European Union (Scoreboard) and the G-20 (Indicative Guidelines). Insofar as most of the imbalance indicators considered have a strong financial component, it also has close links to the literature relating financial and business cycles (Claessens et al, 2011 or Borio and Disyatat, 2011). Especially relevant is the recently published working paper by Borio et al. (2013), which using a somewhat different methodology to refine the traditional output gap estimates reaches very similar conclusions. Finally, in the Spanish case, the papers of both Campa and Gavilán, (2006) and Estrada et al. (2010) have stressed the relevance of external imbalances to account for sustainable growth.

The document is organised as follows. In Section 2, macroeconomic imbalance indicators are discussed and some stylised facts on their interaction with standard estimates of potential growth are presented. This will show, first, that although potential growth estimates over time (real-time) are not correlated with inflation, they are correlated with some of the indicators of imbalances considered; and second, after the crisis, as imbalances have been corrected, there have been important revisions to the estimates of potential growth. Section 3 presents the methodology used to estimate sustainable growth rates. The overview of the results is presented in Section 4, which details the relevant imbalance indicators for each of the five countries considered, the contribution of factors of production to sustainable growth and the reassessment of the output gap. The final section summarises the results and proposes refinements in this methodology to be incorporated in the future.

## 2 Macroeconomic imbalances and potential growth

### *2.1 Indicators of macroeconomic imbalances*

In recent years there has been a significant number of contributions to the literature on imbalance indicators. This is due to the consensus among analysts and policymakers on the relevance of imbalances for explaining the current crisis and the need to correct them before starting a new period of robust, sustainable and balanced growth. In fact, several international organisations have developed various frameworks for the evaluation and early detection of macroeconomic imbalances.

Last year the European Union introduced the Macroeconomic Imbalances Procedure (MIB) to monitor the behavior of imbalances in their Member States, along similar lines to the Excessive Deficit Procedure (EDP). This procedure includes an Alert Mechanism Report (AMR), which, on the basis of a *scoreboard* of ten economic indicators, identifies the EU member states for which a further in–depth review of structural issues is warranted. The indicators considered in the AMR cover external and domestic imbalances, including prices (such as competitiveness), flows (current account balance or private sector credit, for example) and stocks (public debt, among others).[2] One year earlier, the G-20 launched a procedure to analyse the economic sustainability of its members, through the Framework Working Group (FWG). Similarly to the European Union, Sustainability Reports (SR) should be drafted for those countries where the *Indicative Guidelines* (IG) show risks of having or developing imbalances. The IG include six indicators covering, once more, internal and external imbalances (see, IMF, 2011).

Based on these procedures and on the evidence presented, for example, in Frenkel and Saravelos (2012), we have considered the fifteen possible indicators of imbalances shown in Table 1 (for a more detailed definition, see Appendix A). The indicators can be classified in three groups. First, those based on the behaviour of prices, including the real effective exchange rate for the external sector, and the Consumer Price Index (CPI) and the GDP deflator for the domestic sector. All of them are expressed in first differences to capture the level of inflation. Prices are usually the economic variable that is first to react to developments in activity. In that respect, they can be considered as the leading indicators of imbalances. However, as earlier demonstrated, for different reasons their response to activity in the past decade has been scant, meaning that additional indicators are needed to incorporate other macroeconomic imbalances into the analysis of sustainable growth.

The second group includes real flow variables. These indicators should move in phase with activity, but with much higher volatility, thus facilitating the identification of the cycle. In this category we have analysed the current account from the external perspective, and private and public balances (and their components), housing investment and the share of the non-tradable sector from the domestic side (all of them as a percentage of GDP).

Finally, the third group of imbalance indicators is real stocks, also as a percentage of GDP. The problem with this group of indicators is that while they show a very high (though lagged) correlation with activity when the cycle is expansionary, the correlation disappears in

**2.** The rationality of this choice, the data sources and the specific treatment of each indicator are discussed in European Commission (2012).

recessions. The specific indicators considered in this group are net foreign assets for the external sector, and private and public debt for the domestic one (also as a percentage of GDP).

**Table 1. Macroeconomic imbalances**

| Variable | Description |
|---|---|
| Real effective exchange rate (first difference) | Real effective exchange rates CPI based |
| CPI (first difference) | National consumer price index (All-items, yearly average) |
| Current account balance / GDP | Net lending (+) or net borrowing (-): total economy |
| Trade balance / GDP | Real trade balance |
| Private balance / GDP | Net lending (+) or net borrowing (-): Households and Non-Financial Firms |
| Private savings / GDP | Gross savings: Households and Non-Financial Firms |
| Private investment / GDP | Gross fixed capital formation - Gross fixed capital formation of the general government |
| Residential investment / GDP | Gross fixed capital formation at current prices: dwellings |
| Public balance / GDP | Net lending (+) or net borrowing (-): general government |
| Public savings / GDP | Gross saving: general government |
| Public investment / GDP | Gross fixed capital formation: general government |
| Non-tradable sector value added / GDP | Value added of services and construction (2005 prices) |
| International investment Position / GDP | |
| Private debt / GDP | Private sector gross debt |
| Public debt / GDP | General government consolidated gross debt |

### *2.2 Stylised facts*

Standard potential output methodology considers CPI inflation a sufficient statistic of all macroeconomic imbalances. Therefore, one required property of standard potential output estimates would be for them to be unrelated to other macroeconomic imbalances. Another desirable property of real time potential growth estimates is that they should be unrelated to ex-post output gaps. Both elements might entail relatively minor revisions of potential growth estimates when new information arrives. However, the following stylised facts reveal that both desirable properties do not hold and, therefore, the standard potential growth estimates are providing misleading signals of the magnitude of the economic slack and, ultimately, of the imbalances that an economy faces.

As stated in the introduction, CPI inflation appears not to be a sufficient statistic of economic imbalances and, hence, the estimates of potential output might not be properly reflecting the economic growth that an economy can attain with its resources and technology. To ascertain whether that possibility holds formally, we test to what extent the potential output growth estimates made over time –real time– are systematically associated with the changes in the set of variables defined in Table 1, which are considered to capture economic imbalances. We use the real-time estimates of potential growth reported by the European Commission and by the US Congressional Budget Office.[3] The significance of these relationships is assessed by estimating 8-year window rolling bivariate regressions for the pooled data of United States, United Kingdom, Spain and Germany[4] of potential growth estimates and the corresponding imbalance indicator.[5] China is

**3.** We also considered OECD's potential growth real time estimates and the stylised facts hold.

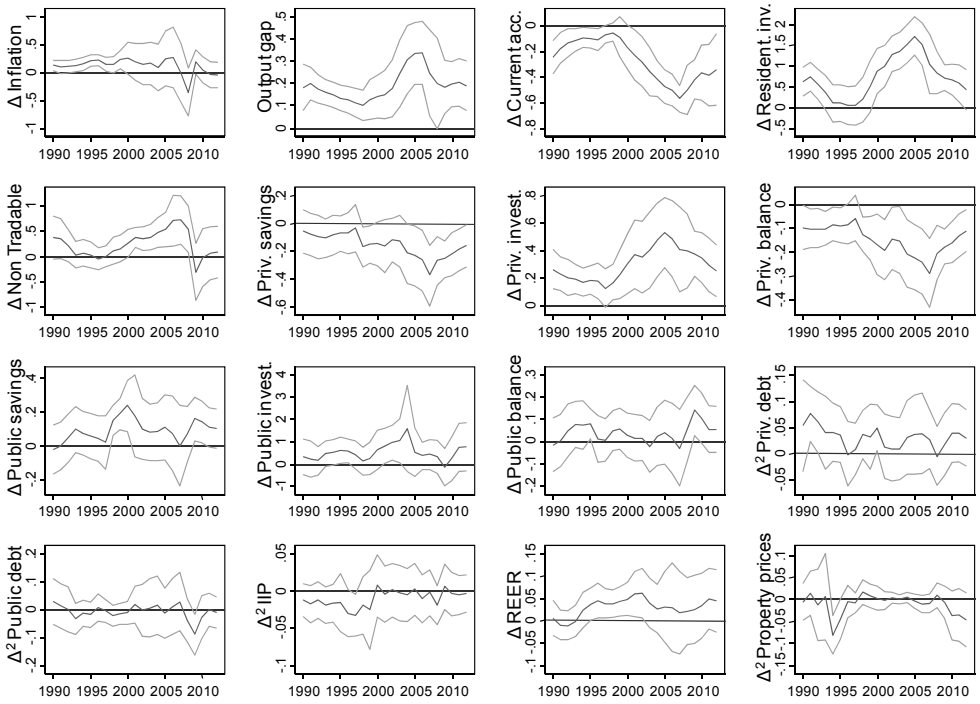
**4.** As a robustness test, we have also performed similar exercises, but regressing real-time potential growth with the cyclical deviations of the imbalances and with the absolute value of the cyclical deviations of these imbalances (instead of with the changes in the imbalances). In overall terms, the same stylised facts hold.

**5**. In the rolling regressions, we differentiate these variables until the unit root tests accept they are stationary.

not included in this analysis since estimates of real-time potential growth are not available for this country.[6]

**Figure 3. Simple regression coefficient with real-time potential growth**

(assessed in t+1, 95% confidence interval)




Source: Own calculations. Note: All variables expressed in GDP terms with the exception of inflation, output gap, real effective exchange rates and property prices

The coefficients of these rolling regressions and the 95% confidence bands are displayed in Figure 3. The first result is that, as expected, real-time potential output is effectively uncorrelated with inflation developments. Second, the ex-post output gap is clearly associated with real-time potential growth,[7] which is an implicit recognition that such potential growth estimates did not fully capture the temporary component of GDP and were largely uncertain.

Third, the estimates of potential growth are correlated with different measures of external imbalances (such as the current account balance) or domestic ones (e.g. private sector balance or residential investment). As shown in Figure 3, this has been particularly acute in the last decade, when inflation developments have been increasingly decoupled from economic slack. The imbalances that present stronger correlations are the current account, residential investment, private investment and private balance, all of them related to asset price inflation and financing needs. In other words, either the financing needs of the country or those of the private sector seem to be those most related to the estimates of potential growth. Both stocks (the accumulation of past imbalances) and prices appear to have a much weaker relationship to potential growth.

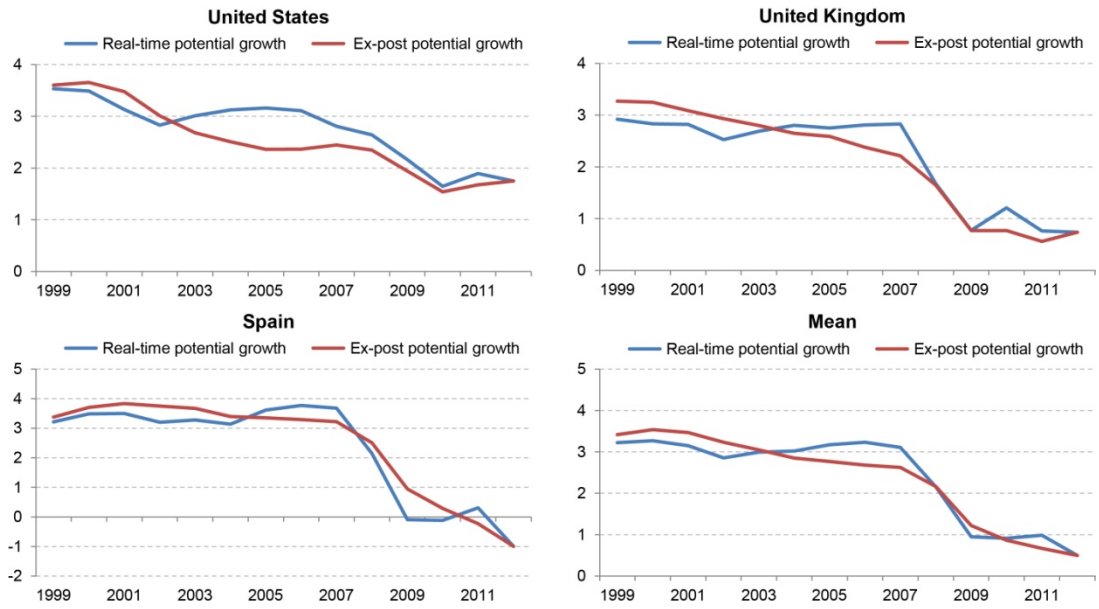
**6.** The full sample consists of a set of five countries: USA, China, Germany, UK and Spain in the period 1970-2011. In the case of Germany, we build an 'artificial Germany' applying the growth rates and ratios from Federal Republic backward to the Germany aggregate in 1991. The bulk of the data considered came from AMECO, US Congress Bureau Office and Datastream. In the case of China, we relied on national sources and estimates from capital stock build by Dragonomics (2011). In China, in any event, there is a very limited amount of data and, thus, we have applied a simplified approach.

**7.** By construction, real-time potential growth and real-time output gaps should be uncorrelated.

Fourth, real-time potential growth estimates tend to increase when imbalances are rising (i.e. larger current account deficits) and to decrease when correcting. This fact is better grasped in Figure 2, which plots the current account balance and potential growth.

Although not shown, these correlations diminish significantly when ex-post potential growth estimates are considered instead of real-time estimates. This suggests potential growth tends to be revised substantially ex-post when the fallout from the imbalances is reflected in a correction of the activity. As can be seen in Figure 4, for the countries with external deficits before the crisis, the downward revision of potential growth has been most relevant. These revisions to potential growth are correlated with the widening of imbalances and with economic slack (measured by the output gap). This implies that real-time estimates provide incorrect signals about the cyclical situation of the economy.

**Figure 4. Real-time and ex-post potential growth (%)**




Source: Own calculations

## 3 Methodology

There are various different methodologies available for estimating the output gap and potential GDP growth. From the perspective of the amount of information used, methods can be classified as univariate or multivariate. The former only use information on the variable to be disaggregated (GDP, industrial production, the unemployment rate, etc.), its trend and the deviations from that trend. This framework is not adequate for the purpose of this paper, as it does not include the information contained in the indicators of imbalances. Multivariate methods should, therefore, be considered instead. Among these, the production function approach seems to be the most suitable, since it takes into account the technological capacities of the economy and the primary productive factor endowments. Another advantage of this approach for our purposes is that it also allows a breakdown of the contribution of each productive factor to growth, so that it allows any differences in the relevance of the various imbalance indicators to each component of the production function to be detected. This approach is also appealing as it is the one most commonly used by international institutions, such as, for example, the OECD (see Giorno et al, 1995) and, more recently, the European Commission (see D'Auria et al, 2010) to estimate the cyclical and trend components of GDP.

### *3.1 The production function approach*

A production function is a mathematical tool summarising the productive process of an economy. At the aggregate level, it is assumed that production (*Y*) requires the involvement of two primary inputs, capital (*K*) and labour (*L*), and that technological progress (total factor productivity, *TFP*) is possible. Assuming that the production function presents constant returns to scale and is twice differentiable, the growth rate of production can be expressed as follows:

$$\Delta y = \alpha \Delta l + (1 - \alpha)\Delta k + \Delta tfp \qquad [1]$$

where lower case letters represent the corresponding variable in logs, $\Delta$ is the first difference and $\alpha$ is the elasticity of output with respect to labour. The first order profit maximization condition of the producing firm implies that, under perfect competition in the input and product markets, $\alpha$ will be equal to the income labour share.

Expression [1] has four observable variables (output, labour, capital and the labour share of income); therefore, under the above conditions, *TFP* growth can be obtained as a residual. To obtain the series of sustainable growth rates ($\Delta y^*$) it is necessary to evaluate the sustainable levels of the primary factors of production and total factor productivity (*Δl*, Δk* and Δtfp**), weighted by the labour share of income. This approach is basically the same as that considered to estimate potential growth. The major differences arise in the identification of the sustainable/standard potential factors of the production function. Table 2 summarises these differences, which are explained in detail below.

**Table 2. Methodological differences with respect to the standard approach**

| | | Standard Potential | Sustainable |
|---|---|---|---|
| **Effective Labour** | Working age population | Observed | Filtered* |
| | Participation rate | Filtered* | Adjusted by imbalances |
| | Unemployment rate | Adj. by inflation (Phillips curve) | Adjusted by imbalances |
| | Hours per worker | Filtered* | Adjusted by imbalances |
| **Effective Capital** | Productive | Observed | Adjusted by imbalances |
| | Residential | | Adjusted by imbalances |
| | Capacity utilisation | - | Adjusted by imbalances |
| **Total Factor Productivity** | | Filtered* | Adjusted by imbalances |

* Using univariate filtering.

**a.** Sustainable labour growth

The best measure of the labour used in the productive process is the total number of hours worked. This variable is the product of the number of persons employed (*E*) and the average number of hours worked per person (*H*). *E* can be calculated as the product of three variables: i) the population of working age (*P*) ii) the participation rate (*A*); and iii) one minus the unemployment rate (*U*). Therefore, the growth of labour can be disaggregated as follows:

$$\Delta l = \Delta p + \Delta a + \Delta(1-u) + \Delta h \qquad [2]$$

To obtain sustainable labour growth it is necessary to identify the sustainable growth rate of these four variables, as all of them could be influenced by the imbalances. Traditionally, in the estimation of potential labour growth, the potential working age population is proxied by the observed population, insofar as, apart from net immigration, this is a predetermined variable not influenced by the current economic situation. Standard potential participation rate and hours worked per person are estimated by smoothing their observed counterparts with a univariate filter. These variables can be influenced by economic conditions, since, in general, it is easier to adjust hours to shocks than staff and population can decide to leave or enter the labour market depending on conditions. Standard potential unemployment is obtained in the context of a *Phillips curve* estimate, which uses inflation to identify the part of observed unemployment which does not increase the inflation rate (NAIRU). In this paper, using a multivariate (pseudo-) Phillips curve approach (see Section 3.2 for the technical details), the four variables determining labour growth are adjusted for the evolution of the (statistically relevant) imbalance indicators presented in the previous section, including inflation.

Once the imbalance-corrected components of these variables are identified, it is possible to obtain the sustainable labour growth rate of the economy by simple aggregation:

$$\Delta l^* = \Delta p^* + \Delta a^* + \Delta(1-u^*) + \Delta h^* \qquad [3]$$

**b.** Sustainable capital growth

As in the case of population, the most standard methodology identifies the potential capital stock with the observed one. One reason for this treatment is that the capital stock is constructed by accumulating past investment. Therefore, although investment is a highly pro-cyclical variable in all the countries considered, the depreciation rate used in the calculations significantly reduces the pro-cyclicality of the stock. However, this approach does not take into account that the capital stock is not always used with the same intensity (see, for example, Nahuis, 2003). In fact, most of the countries collect information from surveys on capacity utilisation (*CU*) in manufacturing, which

shows important fluctuations over the business cycle. Although, admittedly, this information does not include the service sector, the synchronisation of the business cycle among sectors suggests it could be a good proxy for the whole economy.

There is an additional difficulty with this productive factor: the capital stock includes both residential and non-residential assets. The residential capital stock, when it is owner occupied, does not produce a monetary income flow, although the National Accounts impute it a certain income stream. Even taking into account these imputed rents, its productivity is much lower than that of the productive capital stock. Insofar as a frequently cited indicator of internal imbalances is housing investment, the disaggregation of non-residential and residential capital stocks is crucial to identify sustainable growth. Therefore, our observed variable for capital stock will be constructed as follows:

$$k = cu\ (k_{nr} + \beta\ k_r) \qquad [4]$$

where the sub-index nr stands for non-residential, the sub-index r for residential and $\beta$ is the relative productivity of the residential capital stock. The sustainable capital will be constructed by applying expression [4] to the sustainable counterparts of these three variables, which are obtained with the same methodology as in the case of the employment components:

$$k^* = cu^*\ (k_{nr}^* + \beta\ k_r^*) \qquad [5]$$

***c.*** *Sustainable Total Factor Productivity growth*

Total factor productivity (TFP) growth is closely related to technological progress. This includes product and process innovation, the organisational arrangements of the firm, and, at the aggregate level, the institutional characteristics of the economy, including sectoral specialisation. However, as established above, *TFP* is not an observable variable, so it has to be obtained as a residual. Therefore, TFP growth captures basically that part of output growth that cannot be explained by the evolution of the primary inputs, for a given production function. As a consequence, measured TFP also includes the deficiencies in the measurement of the primary inputs, justifying some statistical smoothing to obtain the potential counterpart. However, it may also be reasonable to think of the temporary elements of TFP as being related to the imbalance indicators we are considering. In that case, removing the temporary component of total factor productivity (*TFP**) as in the previous cases, by considering the informational content of the imbalance indicators, could lead to a more robust proxy of the technological progress of the economy.

Once we have the sustainable counterparts of all the right-hand side variables of the production function, it is straightforward to estimate sustainable growth as follows:

$$\Delta y^* = \alpha \Delta l^* + (1 - \alpha)\Delta k^* + \Delta tfp^* \qquad [6]$$

### *3.2 Adjusting the production function components for imbalances*

The next step is to extract the permanent or equilibrium component for each production factor. The econometric methodology to extract temporary factors from observed variables (*x*) taking into account the interaction with (or the informational content of) other stationary variables (*imb*), following Planas and Rossi (2010), is to use the program GAP for the estimation. Although the statistical details of the implementation of the process can be found in GAP's background documentation note, it is based on state-space models, where parameters are estimated by exact maximum likelihood and the Kalman filter is used to generate the unobserved variables. The starting

point of this bivariate framework is that the observed variable to be disaggregated (the components of the production function in this case) is the sum of a non-stationary trend component (*p*) and a stationary cyclical one (*c*), as follows:

$$x_t = p_t + c_t \quad [7]$$

The behaviour of the cyclical component is described with a second-order autoregressive process:

$$(1 - \rho_1 L - \rho_2 L^2) c_t = \varepsilon_{ct} \quad [8]$$

where $L$ is the lag operator and $\varepsilon_{ct}$ is a white noise innovation with variance $V_c$.

The proposed specification for the trend component is a first order random walk:

$$(1 - L) p_t = \mu_{t-1} + \varepsilon_{pt} \quad [9]$$

$$(1 - L)\mu_t = \mu_c(1 - \delta) + \delta\mu_{t-1} \quad [10]$$

$\varepsilon_{pt}$ is a white noise innovation with variance $V_p$.

Finally, the relation between the variable to be disaggregated and the imbalance indicator that will help to identify the cycle is as follows:

$$imb_t = \varphi_{imb} + \gamma(1 - L) \;\; x_{t-1} + \sum_{i=0}^{r} \pi_i c_{t-i} + \theta_1 imb_{t-1} + \theta_2 imb_{t-2} + \varepsilon_{imbt} \quad [11]$$

where $\varepsilon_{mbt}$ is a white noise innovation with variance $V_{imb}$. This innovation and those of the cyclical and permanent components are not correlated with each other.

This procedure has a long tradition in estimating the permanent component of growth considering other indicators of imbalances, such as the unemployment rate (see, for example, Clark, 1989). However, it also resembles the estimation of the *Phillips curve*, where the imbalance indicator (inflation) allows the cyclical component of the unemployment rate and, therefore, the potential rate (NAIRU) to be identified. In this paper, this bivariate framework is applied to all the components of the production function using the imbalance indicators introduced in Section 3.1.

As there are various imbalance indicators, the optimal approach would be to develop a multivariate approach to jointly incorporate all the informational content of the indicators. This approach proved to be very cumbersome, although a simplified version of it is being worked on. In the meantime, we have developed a two step procedure that seems to be quite robust, i.e. the gains from a multivariate approach are expected to be low, as explained below.

The first step consists in applying the bivariate methodology to all the production function components and all the imbalance indicators.[8] For every component of the production function, we retained the permanent factor estimates obtained with the imbalance indicators which were relevant in expression [11] ($\pi$'s statistically significant) and whose cyclical component

**8.** We have disregarded the imbalance indicators based on prices, to stress the differences with respect to standard potential growth methodology. However, at the end of the paper (Section 4.2) we check that our estimates of sustainable growth are not correlated with inflation. In all cases, the stock imbalance indicators were not relevant in the identification of the sustainable component of the factors of the production function.

had good properties ($\rho_i$'s statistically significant). Table 3 presents the correlations among the changes in the permanent factors retained from this first step. Dashes imply that no imbalance indicator was relevant for that variable (working age population), so the sustainable component is the observed variable, or that only one imbalance indicator was relevant (as will be detailed in the next section). In the other cases, the correlations are always positive, around 0.7 in the worst case and close to one for several factors of production. Therefore, there is a very strong co-movement in the different estimates of the permanent components incorporating the informational content of various imbalance indicators.

In the second step, a common component of all the estimated permanent factors of each production function component is extracted from weighting them according to the root mean square error of that estimate. Table 3 suggests that the loss of information involved in this step will be minor. In fact, when alternative methodologies, such as principal components, are used, the results are similar, with the advantage that there are confidence bands for the common factor. Table 3 shows our estimates of the sustainable part of the different components of the production function to be aggregated using expression [6] to obtain sustainable growth and, as the difference with respect to observed growth, the output gap.

**Table 3. Correlation among estimated permanent factors**

| | USA | UK | Spain | China | Germany |
|---|---|---|---|---|---|
| Working age population | - | - | - | - | - |
| Participation rate | 1.00 | 0.91 | 0.95 | 1.00 | 1.00 |
| Unemployment rate | 0.69 | 0.98 | 0.72 | - | 0.98 |
| Hours per worker | 0.96 | 1.00 | 1.00 | -* | 0.97 |
| Productive investment | 0.97 | - | 1.00 | 0.93 | 0.71 |
| Residential investment | 1.00 | - | 0.83 | - | 0.95 |
| Capacity utilisation | 0.86 | 0.83 | 0.99 | -* | 0.91 |
| Total factor productivity | 1.00 | 1.00 | 1.00 | 0.76 | 0.99 |

Source: Own calculations. * These variables are not available in the case of China.

# 4 Results

## *4.1 Country analysis*

### 4.1.1 UNITED STATES

As pointed out in the methodology, the first stage of the analysis is to identify those imbalances that help to estimate sustainable output growth. In the case of the United States, there is an extensive set of imbalances that help with the identification of sustainable output growth, although the most commonly used are the financing needs of the economy and those of the public and private sectors (Table 4). In fact, the current account, the public and private sector balances, and residential investment are relevant for identifying the permanent and cyclical components of most of the constituents of the production function. This is true at least in the years before the crisis, when large current account deficits were recorded, and private-sector indebtedness rose substantially, partly to finance booming residential investment, whereas government finances started to deteriorate.

In a second stage, we summarise the main differences between the estimates of sustainable and of standard potential output growth (Figure 5):

- In terms of output growth (upper left-hand panel), the major differences between the two estimates are observed in the second part of the 1990s and before and after the Great Recession, when sustainable growth rates are lower than potential growth. After 2009, there is still a negative gap between them. The intuition behind this is that since some of the imbalance indicators are still misaligned with respect to their historical averages, the growth rate that could be achieved without generating further imbalances is still lower than the potential rate.

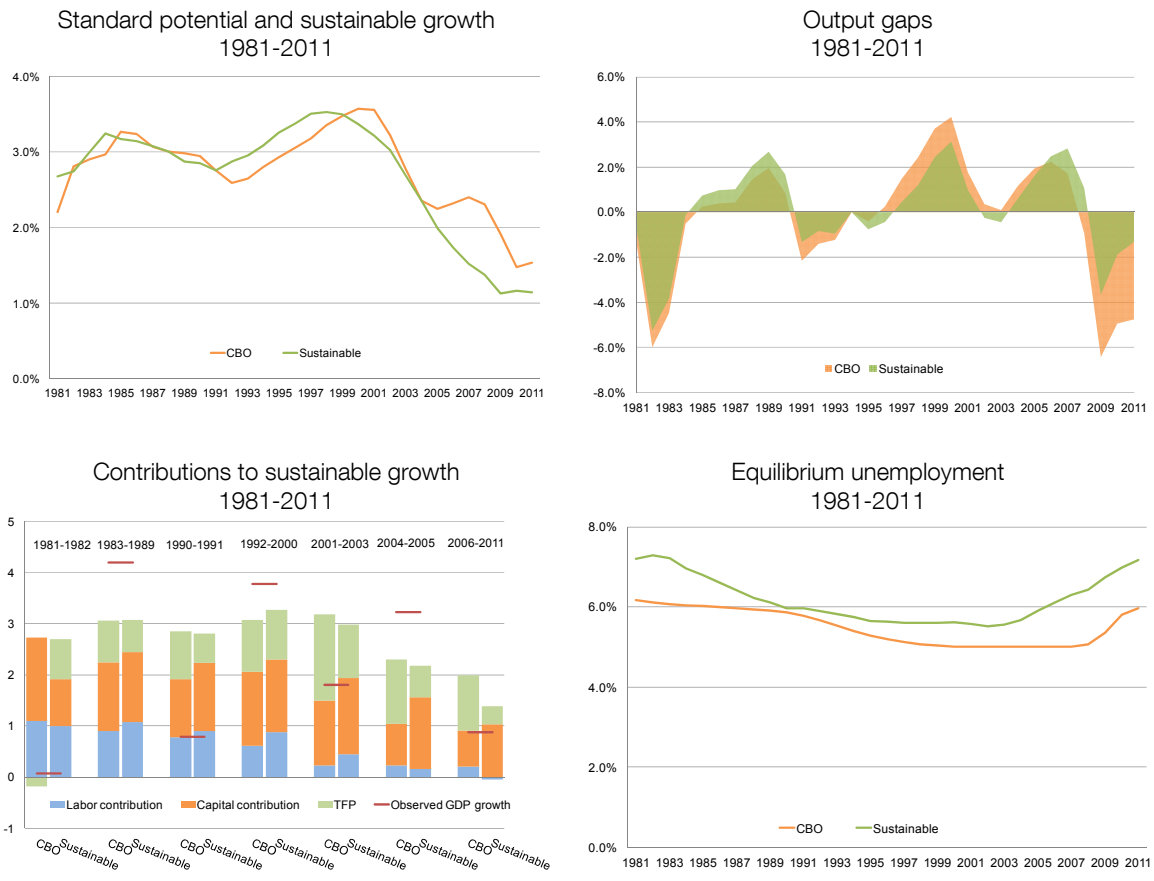
- The upper right-hand panel shows the corresponding output gaps. According to sustainable growth methodology, the output gaps associated with the last two expansionary periods (starting in 1996 and 2003) were of similar magnitude, while the potential growth approach surprisingly reveals a more pronounced cycle in 1996. In this regard, the last expansionary period was longer and slightly more intense, according to sustainable growth rates. Last but not least, a relevant discrepancy is that the current output gap is less negative according to the sustainable growth approach, suggesting more permanent output losses during the recession.

- On the sources of growth (lower left-hand panel), we focus on the recent period to assess the implications of the crisis for sustainable growth rates. Thus, from 2006 onwards, the lower sustainable growth is related to a lower contribution of labour and of total factor productivity than to potential growth. In fact, there is a relevant discrepancy in the equilibrium unemployment estimates between the two approaches (lower right-hand panel), although the definition is probably not exactly the same. In particular, the US Congressional Budget Office (CBO) estimated that the natural rate of unemployment started increasing in the year 2009, by 1 percentage point, while with this methodology the increase was earlier (2005) and by a larger amount (1.5 percentage points).

## Table 4. Relevant imbalances for United States

| Labour | | | Capital | | | Total Factor Productivity |
|---|---|---|---|---|---|---|
| Activity rate | Unemployment rate | Hours worked per employee | Productive investment | Residential investment | Capacity utilization | |
| - Current account balance<br>- Private savings<br>- Residential investment | | | - Private balance<br>- Private savings<br>- Public balance<br>- Public savings<br>- Residential investment<br>- Non-tradable sector | | | - Private balance<br>- Private savings<br>- Public balance<br>- Public savings<br>- Residential investment |
| | - Current account balance<br>- Private investment<br>- Public balance<br>- Public savings<br>- Non-tradable sector | | | - Current account balance<br>- Private balance<br>- Public balance<br>- Public investment | | |
| | | - Private balance<br>- Private savings<br>- Public investment<br>- Non-tradable sector | | | - Current account balance<br>- Private investment<br>- Public investment<br>- Residential investment | |

## Figure 5. Results for United States




Source: Own calculations

4.1.2 UNITED KINGDOM

In the United Kingdom, the most relevant indicators to identify sustainable growth are the current account balance, the financing needs of the public sector and residential investment (Table 5). This is also consistent with the structural weaknesses of the economy: large public deficits, current account deficits related to low productivity growth in manufacturing sectors and a residential boom generating a rise in household indebtedness.

The comparison between the sustainable and potential growth approaches provides some interesting findings (Figure 6).

- The upper left-hand panel shows that the differences in terms of growth are significant. The sustainable growth methodology reports lower growth from the beginning of the millennium, when the imbalances started to build up. After the Great Recession, several imbalances in the United Kingdom may have been being corrected, explaining why the growth rates based on sustainable growth are higher than the estimates of potential growth of the European Commission.

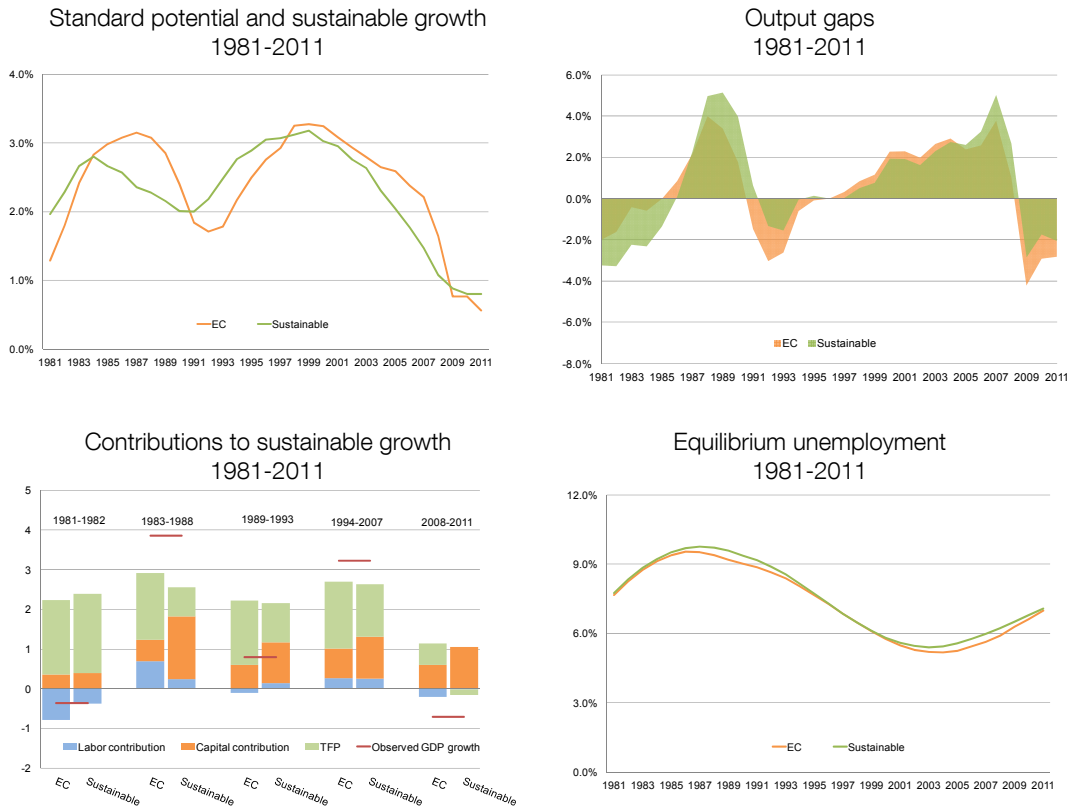
- When comparing the two output gaps (see upper right-hand panel), the last expansionary period was somewhat more intense with the sustainable growth methodology. In addition, the negative output gap was slightly smaller in 2011.

- The differences in the sources of sustainable and potential growth are well defined especially from 2006 onwards (see lower left-hand panel). In relation to the sustainable growth rate, we found a non-negative contribution of labour and a negative contribution of TFP, implying that the bulk of growth is related to capital accumulation.

**Table 5. Relevant imbalances for United Kingdom**

| Labour | | | Capital | | | Total Factor Productivity |
|---|---|---|---|---|---|---|
| Activity rate | Unemployment rate | Hours worked per employee | Productive investment | Residential investment | Capacity utilization | |
| - Current account balance<br>- Residential investment | | | - Public savings | | | - Current account balance<br>- Private balance<br>- Private investment<br>- Public balance |
| | - Current account balance<br>- Public balance<br>- Residential investment | | | - Public savings | | |
| | | - Private savings<br>- Public balance | | | - Private balance<br>- Residential investment<br>- Non-tradable sector | |

**Figure 6. Results for United Kingdom**




Source: Own calculations

4.1.3 SPAIN

In Spain, the current account balance, the private sector financing needs and the public sector balance are the most relevant indicators to identify the cyclical and permanent components of output growth (Table 6). Surprisingly, residential investment is not seen as a relevant indicator, although its strong correlation with the private sector balance suggests that the most relevant macroeconomic imbalances of the Spanish economy are captured.[9] This set-up is in line with the evidence on the origin of the current crisis in Spain. A financial shock resulting from accession to the euro area led to a very rapid increase in private sector indebtedness (the sector's financing needs were ultimately satisfied by other euro area countries' savings), which was used to finance residential investment in a higher extent.

When comparing the results from the sustainable and potential growth approaches, the picture is very similar to that of the United Kingdom, although the differences are larger, especially in the period 2000-2007 (Figure 7).

- In terms of growth (see upper left-hand panel), the sustainable growth approach provides a more stable pattern than potential output growth. Indeed, from 2000 to 2007, the sustainable growth rate was much lower, indicating that severe imbalances were building up in the Spanish economy that were not reflected in inflation. However, after the crisis, the correction of the imbalances meant that the decline in sustainable growth was far lower than that in potential growth.

**9.** The correlation between residential investment and the private balance is -0.9.

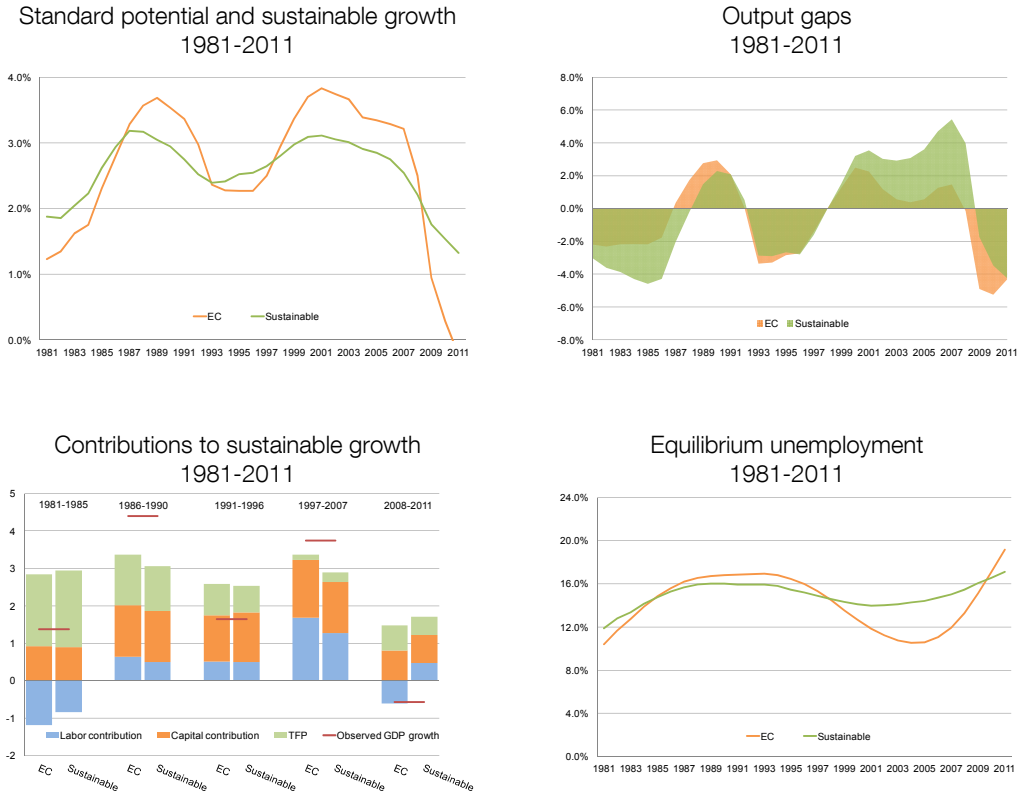
- When comparing the two output gaps (see upper right-hand panel), the differences in the last expansionary period are substantial. In 2007, the output gap reached 6%, which is much larger than the estimates of the European Commission but in line with the findings of Borio et al. (2013). During the recession, the profile is totally different, with a continuous widening in the case of sustainable growth rates.

- The differences in the sources of potential and sustainable growth are clear in the last expansionary and recession periods, and correspond to a very different contribution from labour to growth (see lower left-hand panel). These differences are basically due to the estimate of equilibrium unemployment, which, according to the sustainable growth methodology, fell from 15.9% in 1993 to 14.2% in 2004 and then rose to 17.1% in 2011, compared with 16.9%, 10.5% and 19.2%, respectively, according to the potential growth approach (see lower right-hand panel).

**Table 6. Relevant imbalances for Spain**

| Labour | | | Capital | | | Total Factor Productivity |
|---|---|---|---|---|---|---|
| Activity rate | Unemployment rate | Hours worked per employee | Productive investment | Residential investment | Capacity utilization | |
| - Current account balance<br>- Public balance | | | - Current account balance<br>- Private balance<br>- Public savings | | | - Private balance<br>- Private savings<br>- Public balance<br>- Public savings<br>- Residential investment |
| | - Current account balance<br>- Public balance | | | - Current account balance<br>- Private savings | | |
| | | - Private balance<br>- Public balance | | | - Current account balance<br>- Private balance<br>- Private investment<br>-Public investment<br>- Residential investment | |

**Figure 7. Results for Spain**




Source: Own calculations

4.1.4 GERMANY

In Germany, the non-tradable sector and the private and public sectors are the key indicators to identify sustainable growth (Table 7). This is consistent with the policy recommendations of international organisations for this country, to increase the competition in services in order to improve productivity and, as a result, boost private consumption, which has been subdued for almost two decades.

When the results of the sustainable and the standard potential growth methodologies (Figure 8) are compared:

- Regarding the respective growth estimates (upper left-hand panel), the differences are not large and the major ones arise after 2007. However, in this latter period, potential growth estimates seem to be highly correlated with observed growth, as was the case before the crisis in the previous three countries.

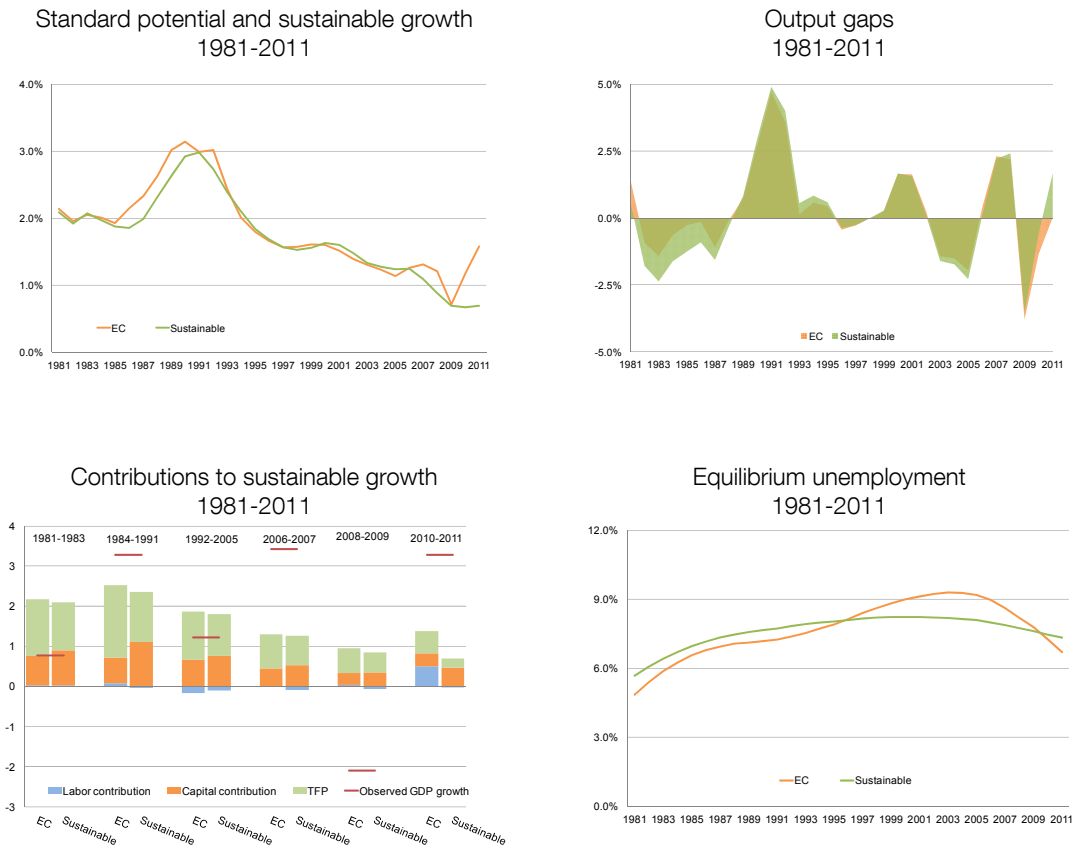
- Regarding the output gap estimates, there are no significant differences between the two procedures (upper right-hand panel).

- With respect to the sources of growth (lower left-hand panel), the lower sustainable growth after 2007 is due to the insignificant contribution of labour. The difference lies in equilibrium unemployment (lower right-hand panel), which diminishes by 2 percentage points in the European Commission case (9% -7%), as compared with a reduction of 0.5 percentage points (8%-7.5%) in the sustainable growth case.

**Table 7. Relevant imbalances for Germany**

| Labour | | | Capital | | | Total Factor Productivity |
|---|---|---|---|---|---|---|
| Activity rate | Unemployment rate | Hours worked per employee | Productive investment | Residential investment | Capacity utilization | |
| - Private investment<br>- Non-tradable sector | | | - Current account balance<br>- Private balance<br>- Public balance<br>- Public savings<br>- Non-tradable sector | | | - Private balance<br>- Public balance<br>- Public savings<br>- Non-tradable sector |
| | - Current account balance<br>- Public balance<br>- Non-tradable sector | | | - Private balance<br>- Private savings<br>- Public savings | | |
| | | - Private balance<br>- Private savings<br>- Residential investment<br>- Non-tradable sector | | | - Current account balance<br>- Private balance<br>- Public balance<br>- Public savings | |

**Figure 8. Results for Germany**




Source: Own calculations

4.1.5 CHINA

In China, given the lack of data, we have applied a streamlined approach to estimate sustainable growth rates and, thus, a simplified production function is considered. In any case, the current account balance and the public balance appear to be the imbalances that best help to identify the permanent and cyclical components of growth (Table 8). This is consistent with the mercantilist exchange rate policy applied by China in the last decade, which fostered the trade surplus and current account until 2007, and the active role of fiscal policy in stabilising economic growth.

As in the case of Germany, the differences between the two methods are small and especially relevant towards the end of the sample (Figure 9). The comparison is made using the potential output estimates of the IMF, given the lack of official estimates.

- In terms of potential growth, the sustainable growth rates are smoother and less related to observed growth than the IMF estimates, especially towards the end of the sample (upper left-hand panel).

- As expected, differences in output gaps are not very relevant (upper right-hand panel).

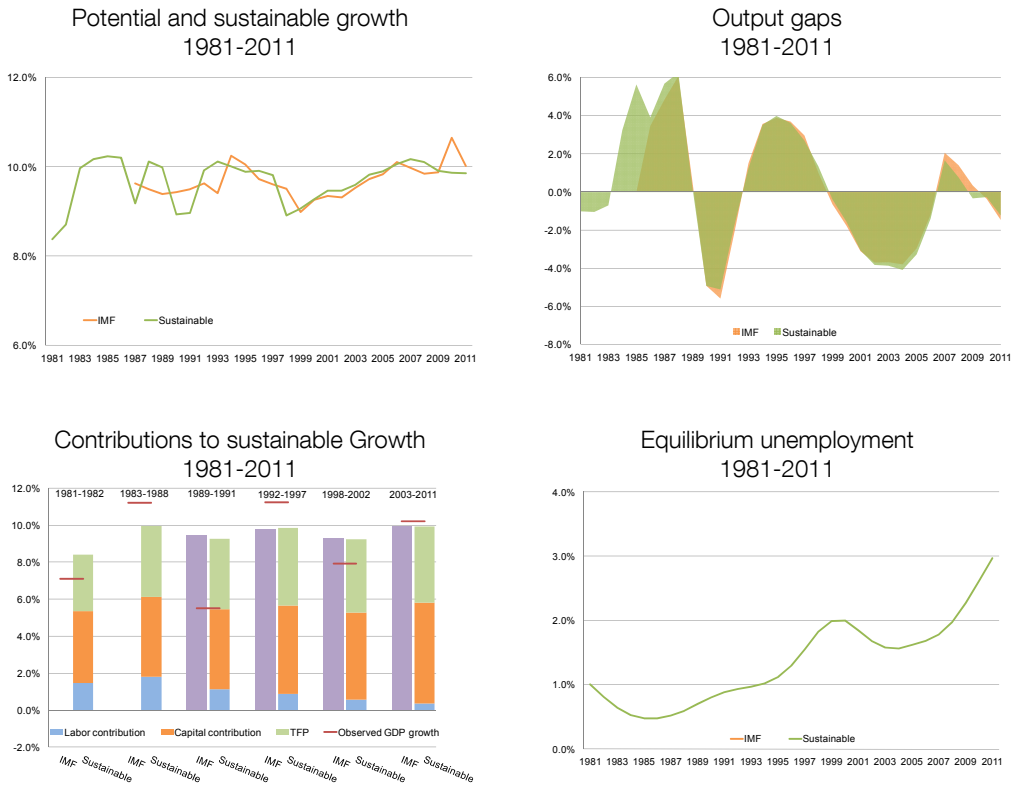
In our estimates the contribution of capital and TFP is remarkable, as is to be expected in the case of a catching-up economy (lower left-hand panel), although we cannot compare with IMF estimates as they it do not cover the factor contributions to GDP growth.

To sum up, the review of the results for the five countries analysed confirms the relevance of the financing needs of the economy, of the private sector and, less frequently, of the public sector as the key indicators of economic slack (see Table 9). In fact, the most relevant indicators for estimating sustainable growth rates are the current account balance and the balances of the private and public sectors. Moreover, for the United States and the United Kingdom, which recorded current account deficits and housing booms, residential investment incorporates information beyond the private sector balance and investment. For Germany, the share of the non-tradable sector is also useful for the identification process.

**Table 8. Relevant imbalances for China**

| Labour | | Capital | | Total Factor Productivity |
|---|---|---|---|---|
| Activity rate | Unemployment rate | Productive investment | Residential investment | |
| - Current account balance<br>- Public balance | | - Private balance<br>- Private savings<br>- Public balance | | - Private balance<br>- Public investment |
| | - Public balance | | - Current account balance | |

## Figure 9. Results for China




Source: Own calculations

## Table 9. Relevant imbalances

| | | United States | Germany | United Kingdom | Spain | China |
|---|---|---|---|---|---|---|
| **Labour** | *Activity rate* | - Current account balance<br>- Private savings<br>- Residential investment | - Private investment<br>- Non-tradable sector | - Current account balance<br>- Residential investment | - Current account balance<br>- Public balance | - Current account balance<br>- Public balance<br>- Trade balance |
| | *Unemployment rate* | - Current account balance<br>- Private investment<br>- Public balance<br>- Public savings<br>- Non-tradable sector | - Current account balance<br>- Public balance<br>- Non-tradable sector | - Current account balance<br>- Public balance<br>- Residential investment | - Current account balance<br>- Public balance | - Public balance |
| | *Hours worked per employee* | - Private balance<br>- Private savings<br>- Public investment<br>- Non-tradable sector | - Private balance<br>- Private savings<br>- Residential investment<br>- Non-tradable sector | - Private savings<br>- Public balance | - Private balance<br>- Public balance | - |
| **Capital** | *Productive investment* | - Private balance<br>- Private savings<br>- Public balance<br>- Public savings<br>- Residential investment<br>- Non-tradable sector | - Current account balance<br>- Private balance<br>- Public balance<br>- Public savings<br>- Non-tradable sector | - Public savings | - Current account balance<br>- Private balance<br>- Public savings | - Private balance<br>- Private savings<br>- Public balance |
| | *Residential investment* | - Current account balance<br>- Private balance<br>- Public balance<br>- Public investment | - Private balance<br>- Private savings<br>- Public savings | - Public savings | - Current account balance<br>- Private savings | - Current account balance |
| | *Capacity utilization* | - Current account balance<br>- Private investment<br>- Public investment<br>- Residential investment | - Current account balance<br>- Private balance<br>- Public balance<br>- Public savings | - Private balance<br>- Public savings<br>- Residential investment<br>- Non-tradable sector | - Current account balance<br>- Private balance<br>- Private investment<br>- Public investment | - Current account balance |
| **Total factor productivity** | | - Private balance<br>- Private savings<br>- Public balance<br>- Public savings<br>- Residential investment | - Private balance<br>- Public balance<br>- Public savings<br>- Non-tradable sector | - Current account balance<br>- Private balance<br>- Private investment<br>- Public balance | - Private balance<br>- Private savings<br>- Public balance<br>- Public savings<br>- Residential investment | - Private balance<br>- Public investment |

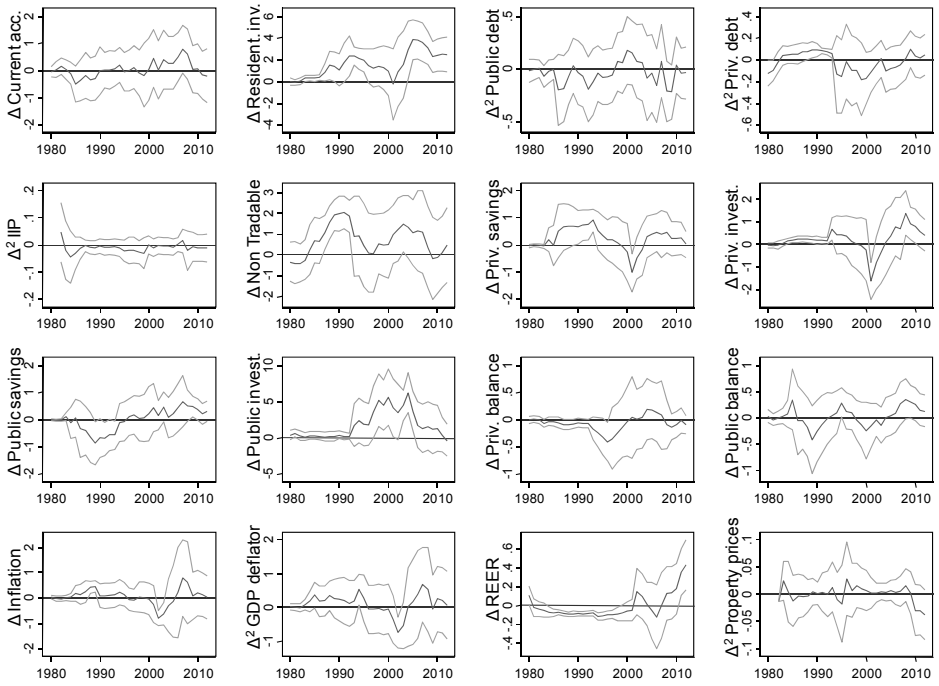
### *4.2 Is sustainable growth related to imbalances?*

As stated in the introduction, a major criticism of standard potential output methodology is that real-time and ex-post potential growth estimates have been associated with several macroeconomic imbalances[10] and, hence, they have been providing incorrect signals about the cyclical momentum of the economy. In this section, we test to what extent our sustainable growth estimates are related to such imbalances and, therefore, assess one of the potential improvements of the methodology proposed in this paper.

Figure 10 shows the statistical relationship between sustainable growth estimates and a set of macroeconomic imbalances (in a similar way to how potential output is shown in Figure 3). First, sustainable growth estimates, like standard potential growth estimates, are not correlated with inflation developments. Second, unlike potential growth estimates, sustainable growth is not correlated with other indicators of imbalances, apart from residential investment. Therefore, we would expect sustainable growth rates to be less prone to revisions than potential growth, at least in this regard. Appendix B summarises the results of a first attempt to show this for the Spanish case. However, this should be proven formally, by generating real-time sustainable growth estimates.

**Figure 10. Simple regression coefficient between sustainable growth rates and changes in selected macroeconomic indicators**

(8 year rolling regression, 95% confidence level)




Source: Own calculations. Note: all variables expressed in GDP terms with the exception of CPI inflation, GDP deflator, real effective exchange rates and property prices

**10.** Figure 3 shows the correlations between real-time potential growth and imbalances. When, ex-post ex-post potential growth is considered most of the relations with imbalances continue to hold.

## 5 Conclusions and further work

During the last period of economic expansion the inflation rate displayed low volatility and a low responsiveness to output developments. Various hypotheses have been put forward to explain this phenomenon, including the globalisation of production and the success of central banks in pursuing the target of low and stable inflation. However, during this period, external and domestic imbalances widened. These imbalances, closely related to the financial sector, suggested that the output growth observed at that time was not sustainable, and, in fact, the crisis led to a significant correction.

Most of the methodologies used to obtain trend growth rates are based on the concept of potential growth. Standard potential growth is estimated in the production function framework, through a traditional *Phillips curve* linking the evolution of the unemployment rate to inflation. Therefore, these estimates of potential growth only take into account one particular imbalance: inflation. While inflation did not respond to output developments in the last expansionary period, standard potential growth showed a statistically significant correlation with other indicators of imbalances, and the ex-post revision of these potential growth rates has been substantial. Therefore, a reassessment of sustainable growth rates, filtering out the imbalances that the economy incurs in expansionary phases, is warranted.

This paper proposes a new methodology to estimate sustainable growth rates that also builds on the production function framework, but considers the informational content of other imbalance indicators apart from inflation. We call these estimates sustainable growth rates to distinguish them from potential growth. For the five countries analyzed, the use of different imbalance indicators provides valuable information to identify the cyclical component of activity, although not all of them are relevant for all countries. The most relevant are the current account and private sector balances. For the deficit countries (US, UK and Spain), the estimates of sustainable growth rates before the crisis are lower than potential growth; during the crisis, sustainable growth rates are higher than potential growth in the countries that are correcting their imbalances. As a result, the signs of the output gaps do not change compared with those obtained using potential growth, but they are higher in the expansionary period and lower during the crisis (in the UK and Spain they could become more negative in 2012). In the case of the second group of countries, sustainable growth is not very different from potential growth before the crisis, but it is slightly lower during the crisis, especially for Germany. However, this does not significantly affect the output gap calculations.

We consider this paper a first step towards obtaining more reliable estimates of sustainable growth, which could be improved in several ways. First, we could discriminate between the impact of refinements in the production function and that of imbalances on the sustainable growth estimates. Second, we need to analyse real time revisions of sustainable growth using this methodology, as a further check of the robustness of the estimates (Appendix B summarises the results of a first attempt for the Spanish case). Finally, integrating the analysis in a real multi-equation framework would improve the empirical approach, and we are confident that our results are robust to this change.

## REFERENCES


BASU. S., and J. FERNALD (2001): Why Is Productivity Procyclical? Why Do We Care?, *NBER Chapters, in: New Developments in Productivity Analysis,* pp. 225-302, *National Bureau of Economic Research, Inc*.

— (2009): What Do We Know (and Not Know) about Potential Output?, *Federal Reserve Bank of St. Louis Review,* July/August, 91(4), pp. 187-213.

BERNANKE. B., (2004): The Great Moderation, intervention at the meetings of the Eastern *Economic Association, Washington.*

BORIO. C., and P. DISYATAT (2011): Global Imbalances and the Financial Crisis: Link or no Link?, *BIS Working Papers,* 346, May.

BORIO. C., P. DISYATAT and M. JUSELIUS (2013): Rethinking potential output: Embedding information about the financial cycle, *BIS Working Papers,* 404, February.

CAMPA. J. M., and A. GAVILÁN (2006): Current accounts in the euro area: an intertemporal approach, *Banco de España Working Paper,* 0638.

CLAESSENS. S., M. A. KOSE and M. E. TERRONES (2011): How Do Business and Financial Cycles Interact?, *IMF Working Paper,* 11/88, April.

CLARK. P. K., (1989): Trend Reversion in Real Output and Unemployment, *Journal of Econometrics,* 40 (2), pp. 15-32.

D'AURIA. F., C. DENIS, K. HAVIK, K. MC MORROW, C. PLANAS, R. RACIBORSKI, W. RÖGER and A. ROS (2010): The Production Function Methodology for Calculating Potential Growth Rates and Output Gaps, *European Economy, Economic Papers,* 420, July.

DRAGONOMICS., (2011): The great rebalancing (I) – Does China invest too much?, *China Insight Economics,* 14 September 2011.

ESTRADA. A., J. F. JIMENO and J. L. MALO DE MOLINA (2010): The Performance of the Spanish Economy in the EMU: The First Ten Years, in JUAN F. JIMENO, ED., SPAIN and THE EURO. The First Ten Years, *Banco de España,* 2010.

EUROPEAN COMMISSION., (2012): Scoreboard for the Surveillance of Macroeconomic Imbalances, *European Economy, Occasional Papers,* 92, February.

FRENKEL. J. A., and G. SARAVELOS (2012): Are Leading Indicators of Financial Crises Useful for Assessing Country Vulnerability? Evidence from the 2008-09 Global Crisis", *NBER Working Papers,* 16047, June.

GIORNO. C., P. RICHARDSON, D. ROSEVEARE and P. VAN DEN NOORD (1995): Estimating Potential Output, Output Gaps and Structural Budget Balances, *OECD Economics Department Working Papers* 152.

IMF (2011): G-20 Mutual Assessment Process: from Pittsburg to Cannes -IMF Umbrella Report, *IMF, Group of Twenty*.

— (2013): Hopes, Realities, Risks: The Dog That Didn't Bark: Has Inflation Been Muzzled or Was It Just Sleeping?, *IMF, World Economic Outlook,* April 2013, Chapter 3, pp. 79-95.

NAHUIS. N. J., (2003): An Alternative Demand Indicator: the 'Non-Accelerating Inflation Rate of Capacity Utilization, *Applied Economics,* 35, pp. 1339–1344

PLANAS. C., and A. ROSSI (2010): Program GAP: Technical Description and User-Manual*, Institute for the Protection and Security of Citizen, Joint Research Centre, European Commission.*

STOCK. J., and MARK WATSON (2002). Has the business cycle changed and why?, NBER *Macroeconomics Annual.*

## APPENDIX A. The Dataset

| Variable | Description | Source | | |
|---|---|---|---|---|
| | | United States | United Kingdom, Spain & Germany (*) | China |
| ***Production function related variables*** | | | | |
| Nominal gross domestic product | Nominal Gross domestic product at market prices. Local currency | AMECO | | CEIC |
| Real gross domestic product | Real Gross domestic product at market prices. Local currency. | AMECO | | CEIC |
| Working age population | Population: 15 to 64 years | AMECO | | CEIC |
| Activity rate | Employment + unemployment (National accounts) / Working age population | AMECO | | Penn World Tables (1) |
| Unemployment rate | Unemployment / Active population (National accounts) | AMECO | | Penn World Tables (1) |
| Hours worked per employee | Total annual hours worked: total economy | AMECO | | - |
| Productive investment | Real residential investment | AMECO | | Dragonomics (2011) |
| Residential investment | Residential investment | AMECO | | Dragonomics (2011) |
| Capacity utilization | Manufacturing capacity utilization | Federal Reserve | European Commission | - |
| Labor income share | Wage share as percentage of GDP at current market prices | AMECO | | Interpolated using urban population from National statistics |
| Productive capital depreciation | Implicit from capital stock series | EUKLEIMS (2) | | |
| Residential capital depreciation | Implicit from residential capital stock series | EUKLEIMS (2) | | |
| Productive capital | Initial capital stock and depreciation from EUKLEIMS and investment from AMECO | EUKLEIMS & AMECO | | Dragonomics (2011) (3) |
| Residential capital | Initial capital stock and depreciation from EUKLEIMS and investment from AMECO | EUKLEIMS & AMECO | | Dragonomics (2011) (3) |
| ***Imbalances indicators*** | | | | |
| Current account balance / GDP | Net lending (+) or net borrowing (-): total economy | AMECO | | CEIC |
| Trade balance / GDP | Real trade balance | AMECO | | CEIC |
| Private balance / GDP | Net lending (+) or net borrowing (-): Households and Non-Financial Firms | AMECO | | CEIC |
| Private savings /GDP | Gross savings: Households and Non-Financial Firms | AMECO | | CEIC |
| Private investment /GDP | Gross fixed capital formation - Gross fixed capital formation of the general government | AMECO | | CEIC (4) |
| Residential investment /GDP | Gross fixed capital formation at current prices: dwellings | AMECO | | CEIC (5) |
| Public balance /GDP | Net lending (+) or net borrowing (-): general government | AMECO | | CEIC |
| Public savings /GDP | Gross saving: general government | AMECO | | CEIC (6) |
| Public investment /GDP | Gross fixed capital formation: general government | AMECO | | CEIC |
| Non-tradable sector value added / GDP | Value added of services and construction (2005 Prices) | AMECO | | CEIC (7) |
| Real effective exchange rate | Real effective exchange rates (CPI based) | | Datastream | |
| CPI inflation | National consumer price index (All-items, yearly average) | AMECO | | CEIC |
| GDP deflator | Price deflator gross domestic product at market prices | AMECO | | CEIC |
| Residential property prices | | BIS | | CEIC |
| International investment Position / GDP | | | IFS, IMF | |
| Private debt / GDP | Private sector gross debt | Flow of Funds Statistics. National sources | | - |
| Public debt / GDP | General government consolidated gross debt | AMECO | | CEIC |

(*) For consistency, we consider an artificial reunified Germany by applying the growth rates of Western Germany before 1991 backwards.
(1) In China: data available of workers and active population
(2) For China, we use the implicit depreciation rates of different types of capital for the rest of countries
(3) Initial capital stocks and implicit deflators taken from Dragonomics. Depreciation from EUKLEIMS
(4) For China: Investment from firms and households from Flow of Funds statistics.
(5) For China: Real estate investment
(6) For China, gross national savings minus private savings
(7) For China, share of tertiary sector over GDP

## APPENDIX B. Robustness of sustainable growth estimates. The case of Spain

As we pointed out in the main text, one major drawback of standard potential growth methodology is that real-time estimates are prone to large revisions when additional information is incorporated. Since the revisions are correlated with different indicators of imbalances, the methodology presented in this paper is expected to reduce these revisions substantially. If this is confirmed, sustainable growth rates should provide a more reliable signal for real-time policy advice.

In this section, we compare the sustainable and potential growth revisions with the data available before and after the 'Great Recession' (in 2007 and 2011). The pure assessment of real-time estimates is highly data consuming, as it requires all GDP components to be re-estimated with the information available at each point in time. However, the largest revisions arise when there is a turning point in activity, that is, when an accelerating GDP path suddenly turns into a slowdown or a decline. Thus, we re-estimate the sustainable growth rates with the information available after 2007 to compare with our estimates after 2011. In 2007, GDP growth was 3.4% compared with 4% in 2006 and 1% in 2008. In 2007, imbalance indicators were peaking: the current account deficit reached 9.6% of GDP and private sector financing needs, 12.5% of GDP, levels that had never previously been recorded in Spain. By contrast, inflation stood at 2.7 %, well below the recent average.

The revisions of sustainable and potential estimates are summarised in Figure B.1 for the years 2004 to 2007, as changes in the previous years are minor with both approaches. Beginning with GDP growth (upper left-hand panel), when information from the crisis (years 2008 to 2011) is included, both potential growth and sustainable growth rates are generally revised down, but the revision of standard potential growth is far larger. In the case of potential growth, the size of the revision is quite stable from 2005 to 2007 (around half a percentage point), and somewhat smaller in 2004. In the case of sustainable growth rates, the size of the revision is a quarter of a percentage point or less for 2005 to 2007 and almost non-existent in 2004.

Labour explains the bulk of the GDP revision (see upper right-hand panel). Under standard potential output methodology, the labour contribution was overestimated by 0.8 percentage points in 2007 (out of 1.7 pp.), while in the case of the sustainable growth methodology the overestimation is much lower (0.1 percentage points out of 1.2).

In the case of the capital contribution (lower left-hand panel), the revisions were negligible with the standard potential growth methodology, and significantly negative with the proposed methodology. Note that capital measurement is approached very differently by these two methodologies. According to the standard potential output one, trend capital is proxied by observed capital (therefore, the only source of revisions are the re-estimation of investment flows in the National Accounts), while the sustainable output methodology also considers the effective use of capital i.e., taking into account capacity utilisation, and the relative productivity of residential and productive capital. Finally, the revisions in the case of TFP growth are very similar with both methodologies, in both cases upwards, as TFP growth rebounded during the crisis.

## Figure B.1. Revisions to Sustainable and Potential Growth. 2004-2007


Sources: European Commission and own calculations.

## BANCO DE ESPAÑA PUBLICATIONS

WORKING PAPERS

1201 CARLOS PÉREZ MONTES: Regulatory bias in the price structure of local telephone services.
1202 MAXIMO CAMACHO, GABRIEL PEREZ-QUIROS and PILAR PONCELA: Extracting non-linear signals from several economic indicators.
1203 MARCOS DAL BIANCO, MAXIMO CAMACHO and GABRIEL PEREZ-QUIROS: Short-run forecasting of the euro-dollar exchange rate with economic fundamentals.
1204 ROCIO ALVAREZ, MAXIMO CAMACHO and GABRIEL PEREZ-QUIROS: Finite sample performance of small versus large scale dynamic factor models.
1205 MAXIMO CAMACHO, GABRIEL PEREZ-QUIROS and PILAR PONCELA: Markov-switching dynamic factor models in real time.
1206 IGNACIO HERNANDO and ERNESTO VILLANUEVA: The recent slowdown of bank lending in Spain: are supply-side factors relevant?
1207 JAMES COSTAIN and BEATRIZ DE BLAS: Smoothing shocks and balancing budgets in a currency union.
1208 AITOR LACUESTA, SERGIO PUENTE and ERNESTO VILLANUEVA: The schooling response to a sustained Increase in low-skill wages: evidence from Spain 1989-2009.
1209 GABOR PULA and DANIEL SANTABÁRBARA: Is China climbing up the quality ladder?
1210 ROBERTO BLANCO and RICARDO GIMENO: Determinants of default ratios in the segment of loans to households in Spain.
1211 ENRIQUE ALBEROLA, AITOR ERCE and JOSÉ MARÍA SERENA: International reserves and gross capital flows. Dynamics during financial stress.
1212 GIANCARLO CORSETTI, LUCA DEDOLA and FRANCESCA VIANI: The international risk-sharing puzzle is at business-cycle and lower frequency.
1213 FRANCISCO ALVAREZ-CUADRADO, JOSE MARIA CASADO, JOSE MARIA LABEAGA and DHANOOS SUTTHIPHISAL: Envy and habits: panel data estimates of interdependent preferences.
1214 JOSE MARIA CASADO: Consumption partial insurance of Spanish households.
1215 J. ANDRÉS, J. E. BOSCÁ and J. FERRI: Household leverage and fiscal multipliers.
1217 ARTURO MACÍAS and MARIANO MATILLA-GARCÍA: Net energy analysis in a Ramsey-Hotelling growth model.
1218 ALFREDO MARTÍN-OLIVER, SONIA RUANO and VICENTE SALAS-FUMÁS: Effects of equity capital on the interest rate and the demand for credit. Empirical evidence from Spanish banks.
1219 PALOMA LÓPEZ-GARCÍA, JOSÉ MANUEL MONTERO and ENRIQUE MORAL-BENITO: Business cycles and investment in intangibles: evidence from Spanish firms.
1220 ENRIQUE ALBEROLA, LUIS MOLINA and PEDRO DEL RÍO: Boom-bust cycles, imbalances and discipline in Europe.
1221 CARLOS GONZÁLEZ-AGUADO and ENRIQUE MORAL-BENITO: Determinants of corporate default: a BMA approach.
1222 GALO NUÑO and CARLOS THOMAS: Bank leverage cycles.
1223 YUNUS AKSOY and HENRIQUE S. BASSO: Liquidity, term spreads and monetary policy.
1224 FRANCISCO DE CASTRO and DANIEL GARROTE: The effects of fiscal shocks on the exchange rate in the EMU and differences with the US.
1225 STÉPHANE BONHOMME and LAURA HOSPIDO: The cycle of earnings inequality: evidence from Spanish social security data.
1226 CARMEN BROTO: The effectiveness of forex interventions in four Latin American countries.
1227 LORENZO RICCI and DAVID VEREDAS: TailCoR.
1228 YVES DOMINICY, SIEGFRIED HÖRMANN, HIROAKI OGATA and DAVID VEREDAS: Marginal quantiles for stationary processes.
1229 MATTEO BARIGOZZI, ROXANA HALBLEIB and DAVID VEREDAS: Which model to match?
1230 MATTEO LUCIANI and DAVID VEREDAS: A model for vast panels of volatilities.
1231 AITOR ERCE: Does the IMF's official support affect sovereign bond maturities?
1232 JAVIER MENCÍA and ENRIQUE SENTANA: Valuation of VIX derivatives.
1233 ROSSANA MEROLA and JAVIER J. PÉREZ: Fiscal forecast errors: governments vs independent agencies?

1234 MIGUEL GARCÍA-POSADA and JUAN S. MORA-SANGUINETTI: Why do Spanish firms rarely use the bankruptcy system? The role of the mortgage institution.

1235 MAXIMO CAMACHO, YULIYA LOVCHA and GABRIEL PEREZ-QUIROS: Can we use seasonally adjusted indicators in dynamic factor models?

1236 JENS HAGENDORFF, MARÍA J. NIETO and LARRY D. WALL: The safety and soundness effects of bank M&As in the EU: Does prudential regulation have any impact?

1237 SOFÍA GALÁN and SERGIO PUENTE: Minimum wages: do they really hurt young people?

1238 CRISTIANO CANTORE, FILIPPO FERRONI and MIGUEL A. LEÓN-LEDESMA: The dynamics of hours worked and technology.

1239 ALFREDO MARTÍN-OLIVER, SONIA RUANO and VICENTE SALAS-FUMÁS: Why did high productivity growth of banks precede the financial crisis?

1240 MARIA DOLORES GADEA RIVAS and GABRIEL PEREZ-QUIROS: The failure to predict the Great Recession. The failure of academic economics? A view focusing on the role of credit.

1241 MATTEO CICCARELLI, EVA ORTEGA and MARIA TERESA VALDERRAMA: Heterogeneity and cross-country spillovers in macroeconomic-financial linkages.

1242 GIANCARLO CORSETTI, LUCA DEDOLA and FRANCESCA VIANI: Traded and nontraded goods prices, and international risk sharing: an empirical investigation.

1243 ENRIQUE MORAL-BENITO: Growth empirics in panel data under model uncertainty and weak exogeneity.

1301 JAMES COSTAIN and ANTON NAKOV: Logit price dynamics.

1302 MIGUEL GARCÍA-POSADA: Insolvency institutions and efficiency: the Spanish case.

1303 MIGUEL GARCÍA-POSADA and JUAN S. MORA-SANGUINETTI: Firm size and judicial efficacy: evidence for the new civil procedures in Spain.

1304 MAXIMO CAMACHO and GABRIEL PEREZ-QUIROS: Commodity prices and the business cycle in Latin America: living and dying by commodities?

1305 CARLOS PÉREZ MONTES: Estimation of regulatory credit risk models.

1306 FERNANDO LÓPEZ VICENTE: The effect of foreclosure regulation: evidence for the US mortgage market at state level.

1307 ENRIQUE MORAL-BENITO and LUIS SERVEN: Testing weak exogeneity in cointegrated panels.

1308 EMMA BERENGUER, RICARDO GIMENO and JUAN M. NAVE: Term structure estimation, liquidity-induced heteroskedasticity and the price of liquidity risk.

1309 PABLO HERNÁNDEZ DE COS and ENRIQUE MORAL-BENITO: Fiscal multipliers in turbulent times: the case of Spain.

1310 SAMUEL HURTADO: DSGE models and the Lucas critique.

1311 HENRIQUE S. BASSO and JAMES COSTAIN: Fiscal delegation in a monetary union with decentralized public spending.

1312 MAITE BLÁZQUEZ CUESTA and SANTIAGO BUDRÍA: Does income deprivation affect people's mental well-being?

1313 ENRIQUE ALBEROLA, ÁNGEL ESTRADA and DANIEL SANTABÁRBARA: Growth beyond imbalances. Sustainable growth rates and output gap reassessment.

BANCO DE **ESPAÑA**
Eurosistema

Unidad de Servicios Auxiliares
Alcalá, 48 - 28014 Madrid
E-mail: publicaciones@bde.es
www.bde.es