

# **OUTPUT GAP: Analysis of GDP and its activities for Brazil (1980-2019)**

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## **Abstract**

This study analyses the evolution of the output gap of Brazilian GDP and its ‘Industry’ and ‘Services’ activities for the period from 1980 to 2019. This breakdown is unprecedented and enriches analysis, enabling the formulation of economic policies focused on these specific sectors. The following methods were used: Production Function, linear, quadratic, and exponential trend extraction, moving averages of 4 to 8 quarters, and the Hodrick-Prescott (HP) filter. Use of the Production Function also enabled identification of the evolution of Total Factor Productivity (TFP) of output and the activities mentioned. Besides the results for Brazil, all calculation methodologies developed for this approach are also presented.

**Keywords:** Potential Output, Output Gap, Hodrick-Prescott (HP) Filter, Production Function, GDP.

**JEL classification:** E00, E17, E66.

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## 1 INTRODUCTION

Studies on potential output have been gaining space in discussions among economists. At times of crisis and economic stress, as in the current world scenario, studies on the theme have become even more important, considering the usefulness of the indicator for the formulation and conduct of economic policies.

As a non-observable variable with various forms of estimation and definition, a fragility found in its study is the discrepancy between results of different estimation methods. With the intention of diminishing such uncertainties, the present study aims to present, for the calculation of the GDP gap and the Industry (Manufacturing + Mining + Construction) and Services (Commerce + Transports + Information Services + Other Services) sector gaps, an estimation of potential output using six statistical metrics and propose a structural approach represented by the Production Function.

The study is divided into four sections, including the introduction. The second section presents the methodology for GDP Production Function, for Industry and Services, and the statistical methods. Analyses of the results are in the third section. The fourth section contains the conclusion.

## 2 METHODOLOGY

Seven methods were used for estimation of the output gap for GDP, for Industry and for Services, which were consolidated into two results: (i) through production function (Cobb-Douglas with constant returns to scale) and (ii) mean of six statistical metrics. The decision to estimate the output gap through seven metrics was made to eliminate any arbitrariness in its measurement, besides making the analysis more robust, since characteristic biases of the statistical methods can be minimized with the combination of the six statistical metrics estimates. Details of the potential output calculation methodologies are found below.

### 2.1 Production Function

The output gap, estimated through the Production Function, was calculated with reference to Study for Discussion no. 17 of the Brazilian Central Bank (*Trabalho para Discussão nº 17, do Banco Central*) (SILVA FILHO, 2001)<sup>†</sup>. This methodology is widely used by important institutions such as the International Monetary Fund (IMF), The Organization for Economic Cooperation and Development (OECD), and the European Central Bank (ECB).

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<sup>†</sup> Available at: < <https://www.bcb.gov.br/pec/wps/port/wps17.pdf> >

The Production Function is based on hypotheses on the structure of the economy, in contrast to methods that are based on hypotheses on statistical properties of temporal series. As potential output should reflect the supply side of the economy, one alternative way of estimating it is through Production Function.

It is assumed that the productive structure of the economy can be represented by a Cobb-Douglas function with unitary elasticity of substitution, constant returns to scale, and decreasing marginal returns on each input. Thus, the unitary elasticity of substitution hypothesis represents the substitution of factors in proportions equal to variations in their prices.

The productive structure of the Brazilian economy can, therefore, be represented through the Cobb-Douglas Production Function, demonstrated in the equation (1):

$$Y_t = A_t K_{t-1}^\alpha L_t^{1-\alpha} \quad (1)$$

In which  $Y$  is the effective GDP,  $K$  represents the services of capital,  $L$  represents the services of the labour factor, and  $A$  represents the contribution of technology, known as Total Factor Productivity (TFP). The exponents  $\alpha$  and  $(1-\alpha)$  can be interpreted, under certain conditions, as the contribution of capital and labour to revenue.

In the traditional form of the Cobb-Douglas Production Function, the output is determined through contemporaneous capital stock. Silva Filho (2001, p.12) state that “in practice, a small adjustment should be made: here, it is supposed that the output in ‘t’ is determined by capital stock at ‘t-1’. This is an intuitive fact given that investment takes some time to produce an increase in the installed capacity”.

Potential output is estimated using the TFP, which is estimated based on equation (1), given that it is also a non-observable variable. The potential level of each input is estimated, and with the associated TFP tendency, potential output is arrived at via the Production Function.

### 2.1.1 Obtaining capital and labour participation

Regarding the participation of capital in income,  $\alpha_t$ , it should be supposed that the Brazilian economy is perfectly competitive, such that remuneration of production factors is equal to their marginal productivity; and it should also be supposed that  $\alpha_t \cong \bar{\alpha}$ , that is, the participation of capital in income when it approximates to its historical mean. Considering these hypotheses to be true,  $\bar{\alpha}$  is equal to the historical participation of capital in national income, data that can be obtained directly

from the System of National Accounts. According to Souza Junior (2001, p. 18), “the participation of labour in revenue has been approximately 51%. This is a lower number than that found in various developed countries but is similar to that observed in all developing countries.” CONSIDERA and PESSOA (2013) provide support for this participation, and thus for the model adopted here  $\alpha = 50\%$ .

### 2.1.2 Measuring capital stock

To measure available capital input in this study, the perpetual inventory method is used, represented by equation (2) below:

$$K_t = (1 - \delta)K_{t-1} + I_t \quad (2)$$

Whereby, I is Investment, taking the Gross Fixed Capital Formation (GFCF) series with seasonal adjustment of the National Accounts and the  $\delta$  parameter is the depreciation rate of capital stock.

From equation (2), it can be seen that to calculate capital stock it is necessary to know the volume of investment, the values of capital stock, and its rate of depreciation. Estimation of the rate of depreciation and initial capital stock present measurement problems, as they are not variables with precise results that are easily measurable, as is the case of investment.

For the rate of depreciation, a value of 5% per year was adopted, this being a value frequently used for this variable. According to Jones (2000, *apud* SILVA FILHO, p. 13), despite being a commonly adopted hypothesis, it is probable that the rate is not constant throughout the cycle, accelerating at times of expansion and decelerating at times of recession.

For initial capital stock estimation, the following formula is used:

$$K_0 = \frac{(1+g)}{(g+\delta)} I_0 \quad (3)$$

In which g represents the mean historical investment growth rate and  $\delta$ , as in equation (2), represents the rate of capital stock depreciation, which is equal to 5%.

Having obtained the capital stock estimation, it is necessary to consider the variations in its usage during the productive process for more correct measurement of its use. Thus, available capital stock,  $K_t$ , is corrected by the capacity utilization rate (CUR) recorded in the same period, as per the equation below:

$$\tilde{K}_t = K_t * CUR_t \quad (4)$$

In which  $\tilde{K}_t$  and  $CUR_t$  are, respectively, the effectively used capital stock and the degree of use of the installed capacity, both measured in period  $t$ .

The available capital stock will be used for the calculation of the TFP series.

### 2.1.3 Measuring labour input

The labour input has fewer uncertainties in its estimation than capital input. It is supposed that available labour stock is equal to the Economically Active Population (EAP), as well as the workers that are outside the labour force because of the “discouragement effect”. Thus, as in the case of capital, so that the EAP more correctly reflects the labour services, it is necessary to correct the series so as to incorporate workers that are outside the labour force.

As in Souza Junior (2001), the EAP was corrected by the unemployment rate, given that the people that are unemployed are not effectively contributing to output, and if they were considered, they would end up distorting the EAP. Thus, the labour input used is:

$$\tilde{L}_t = EAP * (1 - \mu_t) \quad (5)$$

In which  $\tilde{L}_t$  and  $\mu_t$  are the used labour stock and the unemployment rate for the period, respectively.

### 2.1.4 Calculation of Total Factor Productivity

The TFP estimation, represented by the technology variable,  $A_t$ , is obtained directly from equation (1), which when reorganized, is equal to equation (6):

$$A_t = \frac{Y_t}{\tilde{K}_t^\alpha \tilde{L}_t^{1-\alpha}} \quad (6)$$

In which  $Y_t$  is effective GDP, and  $\tilde{K}$  and  $\tilde{L}$  are the used capital and labour factors, found in equations (4) and (5), respectively, and  $\alpha$  is the participation of capital in income.

### 2.1.5 Calculation of Potential Output

To finally determine potential output of the Production Function, it is necessary to substitute the potential levels in the Production Function, that is, of full employment, of the production factors, and of TFP, through the following version of equation (1):

$$\bar{Y}_t = \bar{A}_t \bar{K}_t^\alpha \bar{L}_t^{1-\alpha} \quad (7)$$

In which  $\bar{A}$  is the previously estimated TFP,  $\bar{K}$  is capital stock of full employment and  $\bar{L}$  is the potential level of the labour factor.

Equation (7) is then used to estimate potential output. However, prior to carrying out such calculations, it is necessary to know which capital and labour stock will be used for the estimation.

To know which labour stock will be used, it is necessary to find the natural level of unemployment,  $\bar{\mu}$ , of the Brazilian economy during the period of analysis. As in Souza Junior (2001), it can be supposed that the natural rate of unemployment is the mean of the unemployment rate for the whole period analysed. The potential level of labour is represented in the following equation:

$$\bar{L}_t = \overline{EAP}_t * (1 - \bar{\mu}) \quad (8)$$

To obtain potential capital stock, it is necessary to find the installed capacity utilization rate (CUR) that is compatible with full employment of capital stock. This is done as per equation (9):

$$\bar{K}_t = K_t * \overline{CUR} \quad (9)$$

In which  $K_t$  is the available capital, which is multiplied by  $\overline{CUR}$ , understood as the mean of CUR for the entire period of analysis.

From the TFP of the potential levels of capital and labour, the participation of capital and labour in income, it is possible to arrive at the result for potential output.

## 2.2 Production Function for Industry

For estimation of the Production Function for Industry, the same structure as the previously presented Cobb-Douglas function is used. Some additional hypotheses are adopted for the estimation of this method in the case of each specific economic activity.

### 2.2.1 Measuring the capital stock of Industry

Available capital input is estimated from the method of perpetual inventory, as per equation (2).

In equation 2, I is Investment, using the Gross Fixed Capital Formation (GFCF) series with seasonal adjustment of the National Accounts, previously adjusted by the participation of investment in machines and equipment in the GFCF total. This information on industry investment in machines and equipment was extracted from the Annual Industrial Survey (Pesquisa Industrial Anual) (AIS) of IBGE (Brazilian Institute of Geography and Statistics), as specified in the article by CONSIDERA and Others (2019) "What is Investment" ("O que é investimento"). The parameter  $\delta$  is the rate of

depreciation of capital stock of 5%, also adopted for the Production Function of the economy as a whole.

For estimation of initial capital ( $K_0$ ), equation (3) is used, in which  $g$  represents the mean rate of historical growth of investment (in machines and equipment) and  $\delta$ , as in equation (2), represents the rate of depreciation of capital stock equal to 5%.

Once the estimation of capital stock is obtained, correction of the variations in its use during the productive process is made in the same way as for that aggregated from the economy, that is, it is corrected using the CUR for the manufacturing industry for the same period.

Thus, the available capital stock is found for Industry, which is used for calculation of the TFP of Industry.

### 2.2.2 Measuring labour input to Industry

The hypothesis adopted for measuring the labour input used by Industry is that in which it is well represented by the labour force of the sector. As such, as there is no sectoral unemployment, the labour used is the Occupied Population (OP) series for industry.

This series is used for calculation of TFP for Industry.

### 2.2.3 Calculation of Total Factor Productivity for Industry

The calculation is made from equation (6), in which  $Y_t$  is the effective value added (VA) of deseasonalized Industry,  $\tilde{K}$  and  $\tilde{L}$  are the capital stock and labour input used in Industry, as per sections 2.1.1 and 2.1.2, respectively, and  $\alpha = 50\%$  is the participation of capital in income.

### 2.2.4 Calculation of potential output for Industry

To calculate the potential output of Industry using the Production Function, it is necessary to use the potential inputs of labour and capital in equation (7).

The potential labour input to industry is the sum of the Occupied Population of Industry with the Unoccupied Population of the whole economy. This hypothesis supposes that the potential labour force of industry is composed of those who work in the sector and the entire unoccupied population that could be employed in the sector.

The potential capital input to industry is calculated in conformity with the calculation of potential capital input to the whole economy. The available capital is adjusted by the mean of the historical series of the CUR.

## 2.3 Production Function of Services

The Production Function of the Services sector is estimated in accordance with the previously presented methodologies. As was done with Industry, some additional hypotheses should also be adopted in the calculation of this production function.

### 2.3.1 Measuring capital stock of Services

Using the perpetual inventory method, as per equation (2),  $I$  is Investment in Services, using the Gross Fixed Capital Formation (GFCF) series with seasonal adjustment of the National Accounts, adjusted by the participation of investment in machines and equipment in the GFCF total. The data were extracted from the Annual Services Survey (Pesquisa Anual de Serviços) (ASS) and the Annual Trade Survey (Pesquisa Anual de Comércio) (ATS) as specified in the article by Considera and Others (2019) "What is Investment" ("O que é investimento"). The parameter  $\delta$ , the rate of depreciation of capital stock of 5%, is also used.

The estimation of initial capital ( $K_0$ ) is also made using equation (3), in which  $g$  represents the mean rate of historical growth in investment in Services. Capital stock is corrected by the CUR for the manufacturing industry, as an approximation to the CUR for Services, which has a very short historical series, albeit with similar behaviour.

Thus, the available capital stock of Services is calculated.

### 2.3.2 Measuring labour input to Services

To measure the labour input used in Services, the same hypothesis chosen for Industry is used. It is assumed that the input is well represented by the labour force of the sector. As such, the labour used is the OP series for Services.

This series is used to calculate the TFP of industry.

### 2.3.3 Calculation of Total Factor Productivity for Services

As in sections 1 and 2, equation (6) is also used, in which  $Y_t$  is the effective VA of deseasonalized services, excluding Public Administration, Rent, and Financial Intermediation,  $\tilde{K}$  and  $\tilde{L}$  are the services capital stocks and labour input used in Services, as per sections 3.1 and 3.2, respectively, and  $\alpha$  is the participation of capital in income.

### 2.3.4 Calculation of potential output for Services



To calculate the potential output of Services using Production Function, it is necessary to use the potential inputs of labour and capital in equation (7).

The potential labour input to Services is the sum of the Occupied Population of Services with the Unoccupied Population of the whole economy. This hypothesis supposes that the potential labour force of Services is composed of those who work in the sector and the entire unoccupied population that could be employed in the sector.

The potential capital input to Services is calculated in conformity with the calculation of potential capital input to the whole economy and to Industry. The available capital is adjusted by the mean of the historical series of the CUR.

## 2.4 Mean of the six statistical metrics

It was decided to calculate the mean of statistical methods rather than presenting the individual result for each of the metrics, with the objective of minimizing the discrepancies between the results from these methods. Furthermore, this procedure avoids the arbitrary choice of one of the methods.

The methods are purely statistical, which has the advantage of simplicity and easy application. However, they have disadvantages in the fact that they do not take into consideration any other economic indicator or other variables that represent the structure of the economy. Therefore, they do not efficiently incorporate any occasional shock to the economy. Another negative point is the distortion that is presented in more recent data from the sample, which may underestimate or overestimate the value. To also minimize this fact, projections for 6 quarters ahead are made, so that the distortion does not have such a marked influence on the result of the moment to be observed.

The mean of statistical metrics, therefore, is the mean of potential output extracted from linear, quadratic, and exponential trends, the moving averages of four and eight quarters, and the Hodrick-Prescott (HP) Filter.

### 2.3.1 Linear, exponential and quadratic trends

The trends method is one of the most simple for estimating potential output, as it assumes that output can be decomposed into a trend component and a cyclical component. That is, output trend, which is its potential, presents a constant rate of growth in time.

For this methodology, it is assumed that the growth trend of potential output approximates to a rectilinear function, in the extraction of linear trend (equation 10), to an exponential function in the

extraction of exponential trend (equation 11), and to a quadratic function in the extraction of quadratic trend (equation 12).

$$y_t = a + \beta t + \varepsilon_t \quad (10)$$

$$\ln Y_t = \ln \alpha + \beta_1 t + \ln \varepsilon_t \quad (11)$$

$$Y_t = \alpha + \beta_1 t + \beta_2 t^2 + \varepsilon_t \quad (12)$$

### 2.2.2 Moving averages method

Proposed by Moreira (1985), this method considers that growth in potential output follows a variable rate over time. It proposes construction of potential output with properties similar to the previous, albeit with greater care and adherence in relation to crisis or to the growth of an era, as it does not have a hypothesis of continual growth in potential output. It would therefore have greater adherence to the observed economic cycles.

$$g_t^* = \frac{g_{t-1} + g_{t-2}}{2} \quad (13)$$

The present study proposes going further and calculating the potential output using the moving averages method in different windows, with a lag of four or eight periods, whereby, in this case, each period is a quarter.

### 2.2.3 Hodrick-Prescott (HP) Filter

A widely used measure for estimation of potential GDP is the HP Filter. This methodology minimizes output variance in relation to its long-term trends and seeks to smooth out the trend in relation to effective output.

The filter decomposes temporal series between the portion considered as trend and the cyclical component, considering that the seasonal component has already been removed from the series. It is a simple method that is frequently used to smooth out different types of macroeconomic series.

According to Hodrick and Prescott (1997), the growth components of a series are obtained by solving the following problem of dynamic optimization:

$$\text{Min}_{\{g_t\}_{t=1}^T} \left\{ \sum_{t=1}^T c_t^2 + \lambda \sum_{t=1}^T [(g_t - g_{t-1}) - (g_{t+1} - g_{t-2})]^2 \right\} \quad (14)$$

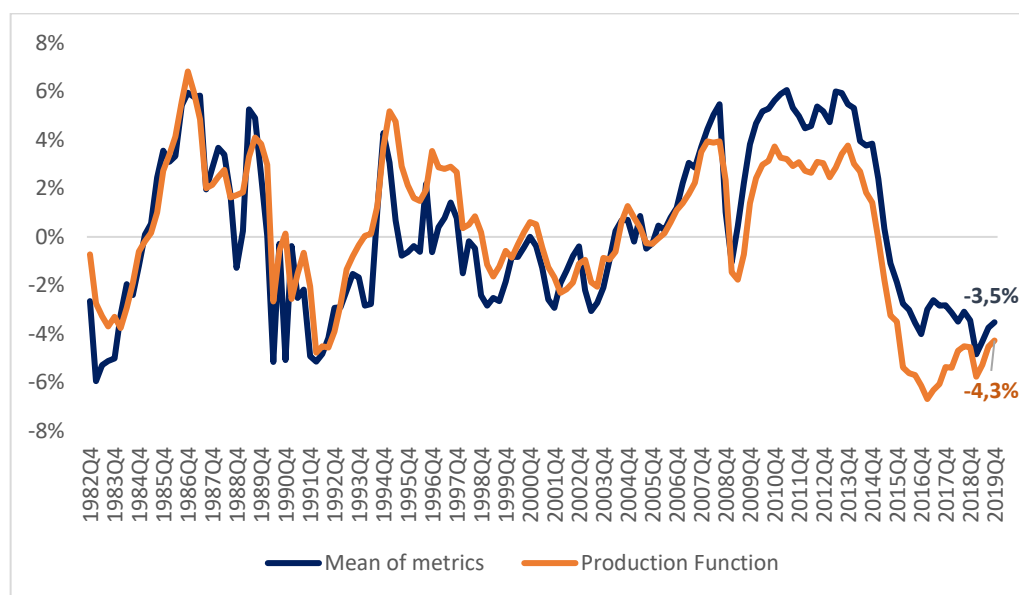
### 3 RESULTS

#### 3.1 Results for GDP

##### 3.1.1. Using the Production Function

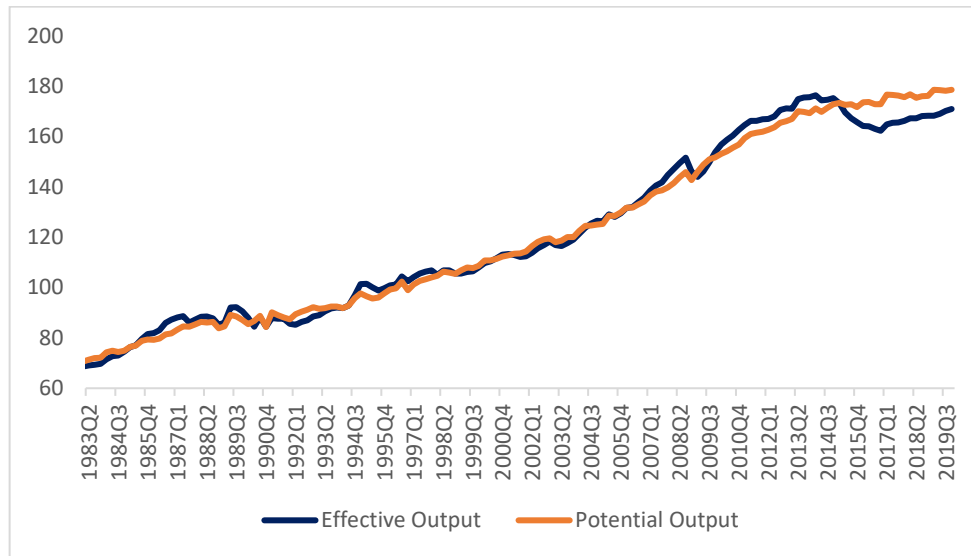
The output gap through the Production Function method had a negative result (-4.3%), in the fourth quarter of 2019, albeit less negative than that observed in the third quarter of 2019 (-4.5%). Using the mean of metrics, the output gap in the fourth quarter of 2019 was -3.5%. In both methodologies, the gaps are close and a little closer than in the second quarter of 2019. For the five years from 2010, the effective output was greater than potential output by around 3 p.p. using the Production Function, and around 5 p.p. through mean of metrics, causing inflationary pressures during the period.

**Graph 1 – Output Gap**



Primary source: IBGE, Cunha (2017). Authors elaboration (2020)

**Graph 2 – Effective and potential output – Production Function**



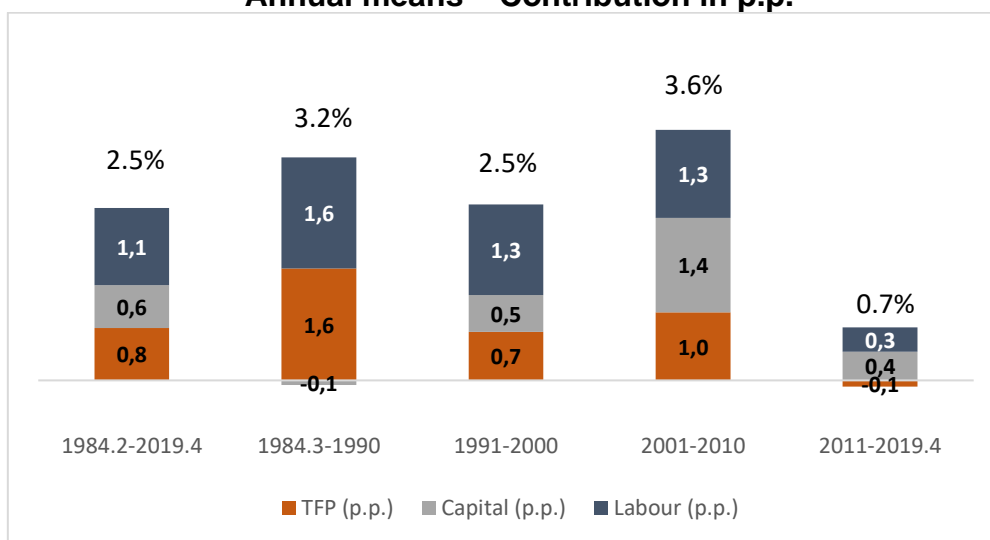
Primary source: IBGE, Cunha (2017). Authors elaboration (2020)

A useful exercise that can be performed using the Production Function is analysis of the effective output through decomposition of the part related to the contribution of capital and labour to TFP. Graph 3 shows the evaluation of effective output for the entire available period and separated by specific periods.

In the thirty-three years of estimates in this study, Brazilian output grew 2.5% per year, mainly as a result of the 1.1 p.p. contribution of the labour factor. The capital factor contributed with 0.6 p.p. and TFP with 0.8 p.p. Being strongly based on the labour factor, such growth is unsustainable in the long-term, given that the increase in this factor reflects the increase in demographic bonus during the period associated with growth in the EAP. It is hoped that with the aging of the population and reduced fertility, the trend is that the labour factor contributes negatively to output growth.

A better vision of what has occurred can be obtained by breaking up the period of analysis. From 1985 to 1990, Brazilian GDP grew 3.2%, on average, per year, with a strong contribution from TFP (1.6 p.p.). From 2001 to 2010, GDP grew 3.6%, capital being the biggest contributor, with TFP presenting the lowest contribution (1 p.p.). The most disastrous period under analysis was that between 2011 and 2019, with TFP contributing negatively (-0.1 p.p.), labour with only 0.3 p.p., and capital with 0.4 p.p., emphasising the poor allocation of capital resources which did not help TFP at all. This performance is alarming given that it demonstrates the unsustainability of growth, whereas developed economies have sustainable growth based on increased productivity, not only on the accumulation of production factors.

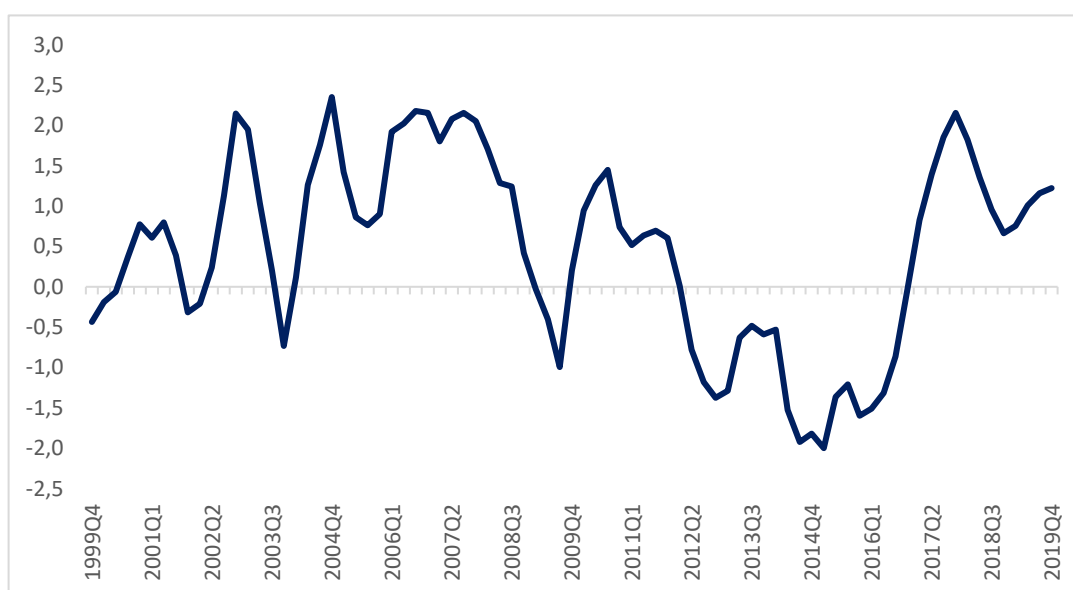
**Graph 3 – Breakdown of effective GDP growth  
– Annual means – Contribution in p.p.**



Primary source: IBGE, Cunha (2017). Authors elaboration (2020)

Graph 4, below, shows the variation in TFP accumulated over 4 quarters. The accumulated rate up to the fourth quarter of 2019 reached a growth of 1.2%, on an ascending trajectory. It can be observed that the TFP had a declining trajectory since the fourth quarter of 2006, which was deepened by the crisis of 2008, recovered momentarily in 2010, then returned to declining to its most negative point (-2%) in the first quarter of 2015, with the fiscal restriction policy of the second mandate of Dilma Rousseff presidency. From there, TFP recovered until the fourth quarter of 2017, when it returned to a decline, presenting a rate of 1.2% in the fourth quarter of 2019.

**Graph 4 – TFP of GDP – Growth accumulated in 4 quarters**



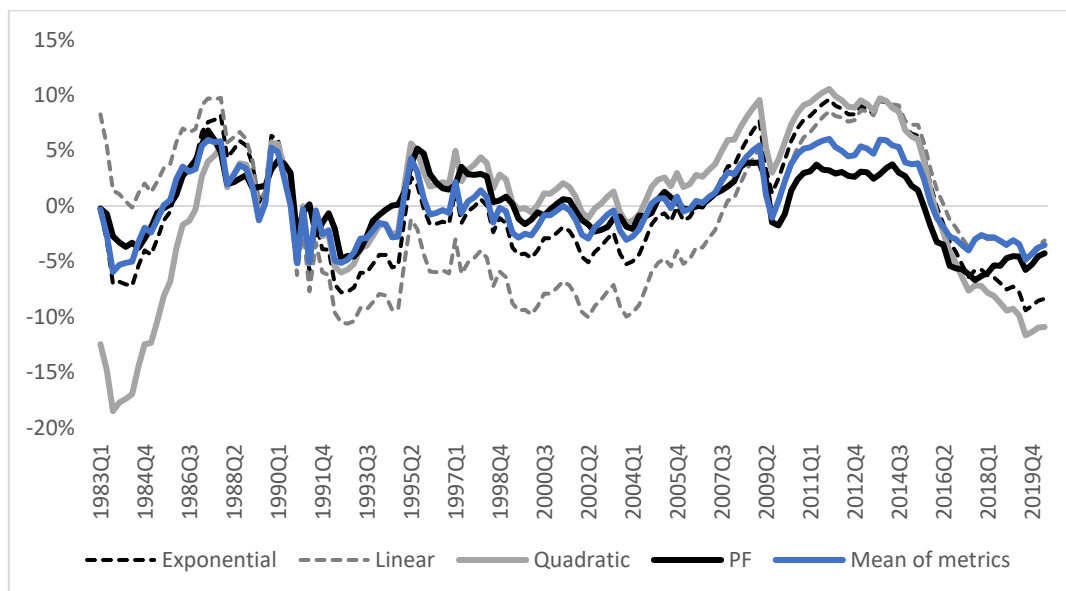
Primary source: IBGE, Cunha (2017). Authors elaboration (2020)

### 3.1.2. Using Statistical Metrics and the Production Function

With the aim of eliminating the effects of over- and underestimation of the tails, characteristic of statistical filters, projections were made in the statistical metrics up to the second quarter of 2021.

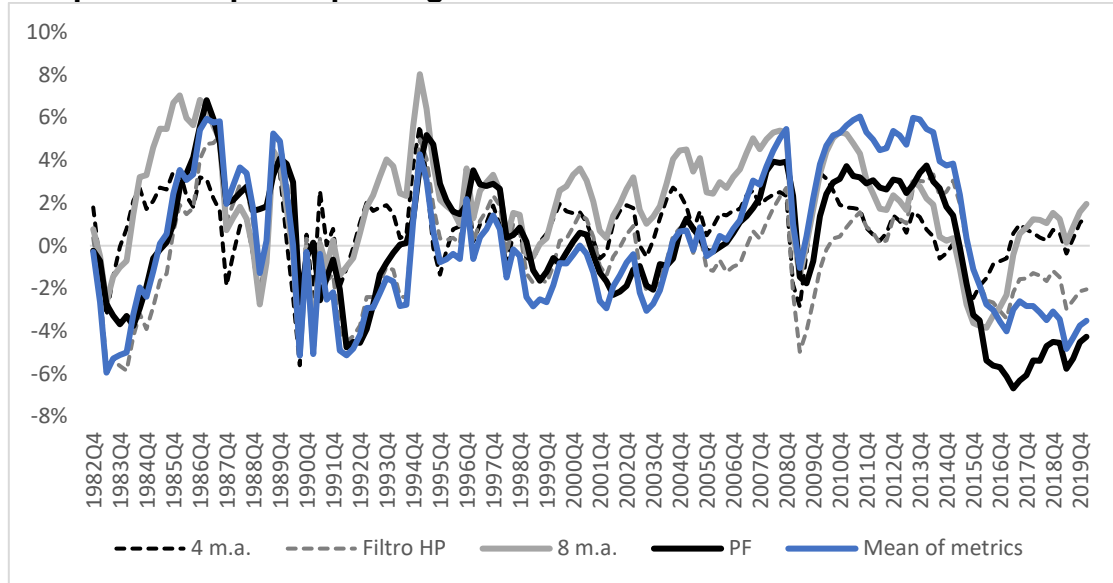
It can be observed in Graph 5 that the gaps calculated through linear and exponential trends presented bias towards lower levels, in the recent period, indicating effective output further from potential output. In turn, gaps measured using quarterly moving averages (4MA and 8MA) and the HP Filter in Graph 6, presented a bias towards higher levels, even including positive results, in the same period, indicating effective output closer to its potential.

**Graph 5 – Output Gap using Production Function and statistical metrics**



Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

**Graph 6 – Output Gap using Production Function and statistical metrics**

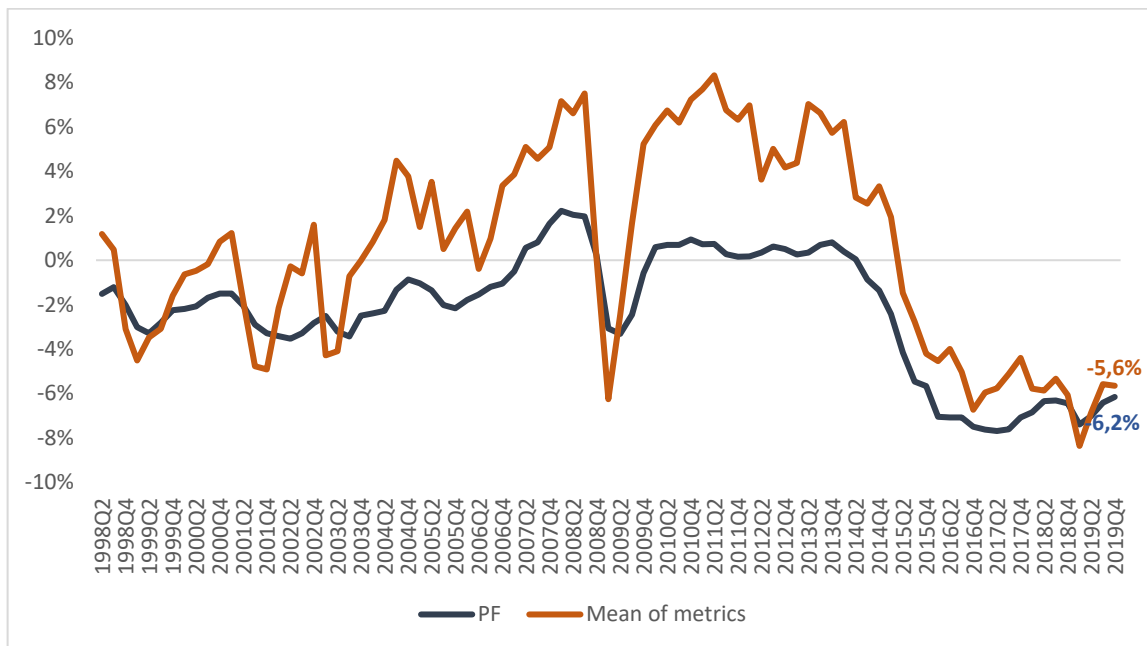


### 3.2 Results for Industry

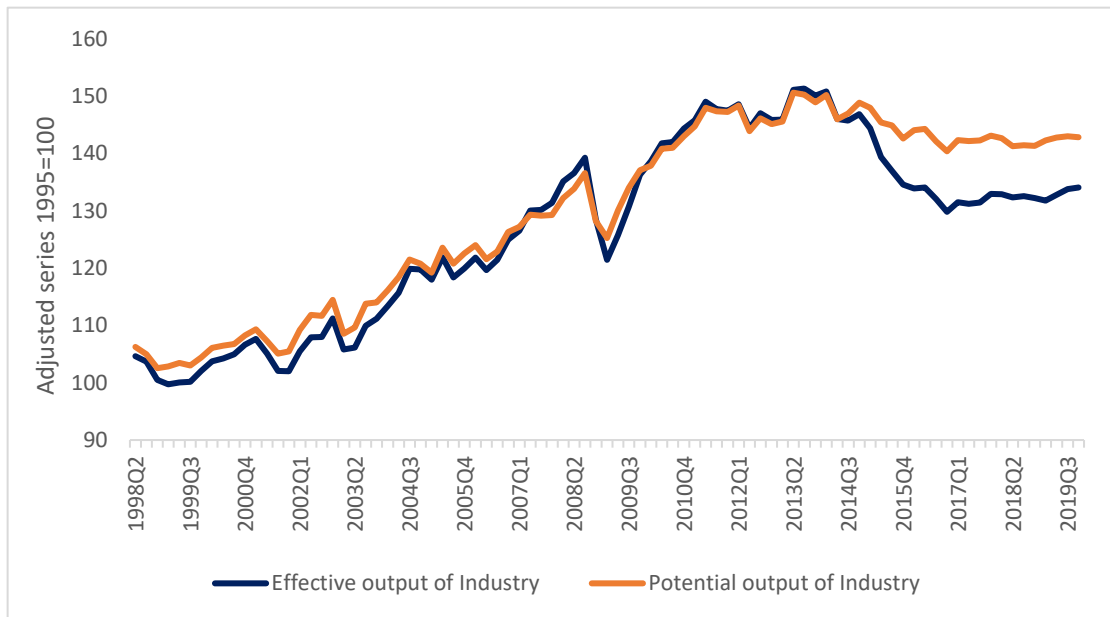
#### 3.2.1. Using Production Function

The output gap for Industry through the Production Function, illustrated in Graph 7, presented a result of -6.2%, and -5.6 through mean of metrics. Both values demonstrate a negative gap in industrial output above that of the GDP and already negative 1 year prior to the GDP.

**Graph 7 – Output gap for Industry**



**Graph 8 – Effective and potential output for Industry – Production Function**



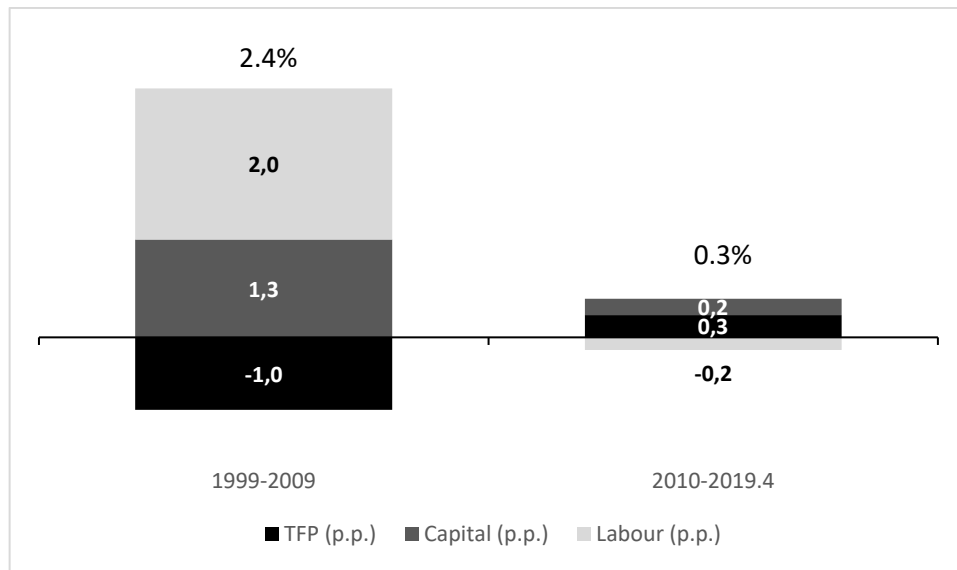
Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

Graphs 7 and 8 above show the dramatic situation of Industry. After spending 9 years operating with a negative gap, there was an improvement from 2010 to 2014 and then five years in the area of negative gaps from 2015, in a range never previously observed in the series presented here.

Upon analysing the decomposition of growth in the effective output of industry, illustrated in Graph 9, it can be noted that there is a large discrepancy between the first and second decades analysed. In the first decade of analysis (1999–2009), effective output grew an average of 2.4% per year, with the main contribution being the input of capital and labour, with a negative contribution from TFP. In the second decade of analysis, effective output grew an average of 0.3% per year, with positive contributions from capital and TFP and a negative contribution from the labour input.



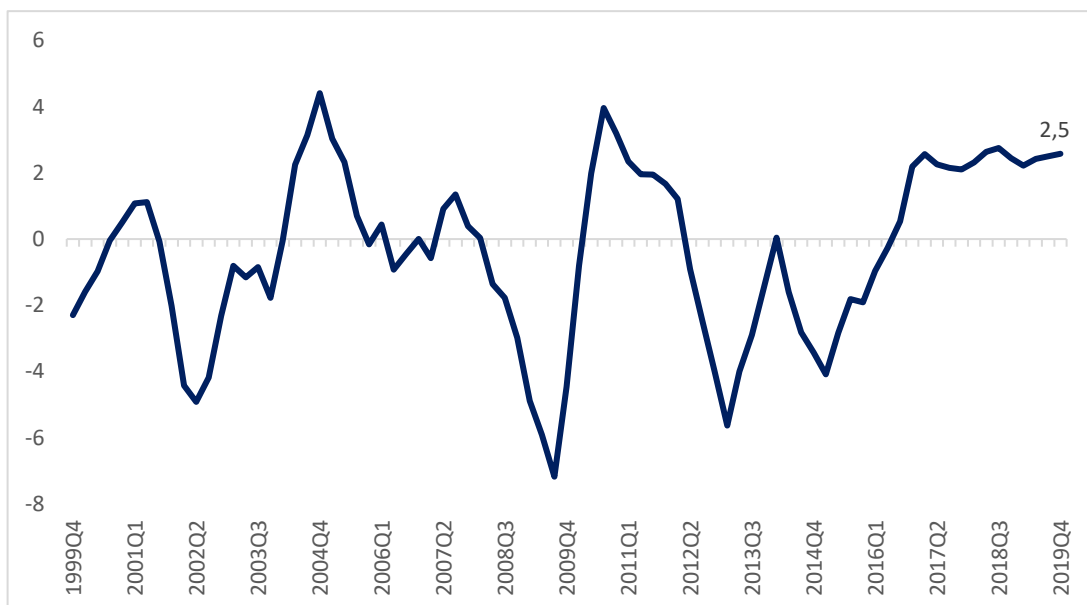
**Graph 9 – Breakdown of effective GDP growth in Industry – Annual means – Contribution in p.p.**



Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

The TFP dynamic, illustrated in Graph 10, reveals a variation in Industry productivity fluctuating between negative rates (40 observations with a mean of -2.5%) and positive rates (35 observations with a mean of +2%). However, from the third quarter of 2016, the rate has been positive, with a mean of 2.2%, improving its contribution to growth in the 2010-2019 period.

**Graph 10 – Graph 4 – TFP of Industry – Growth accumulated in 4 quarters**

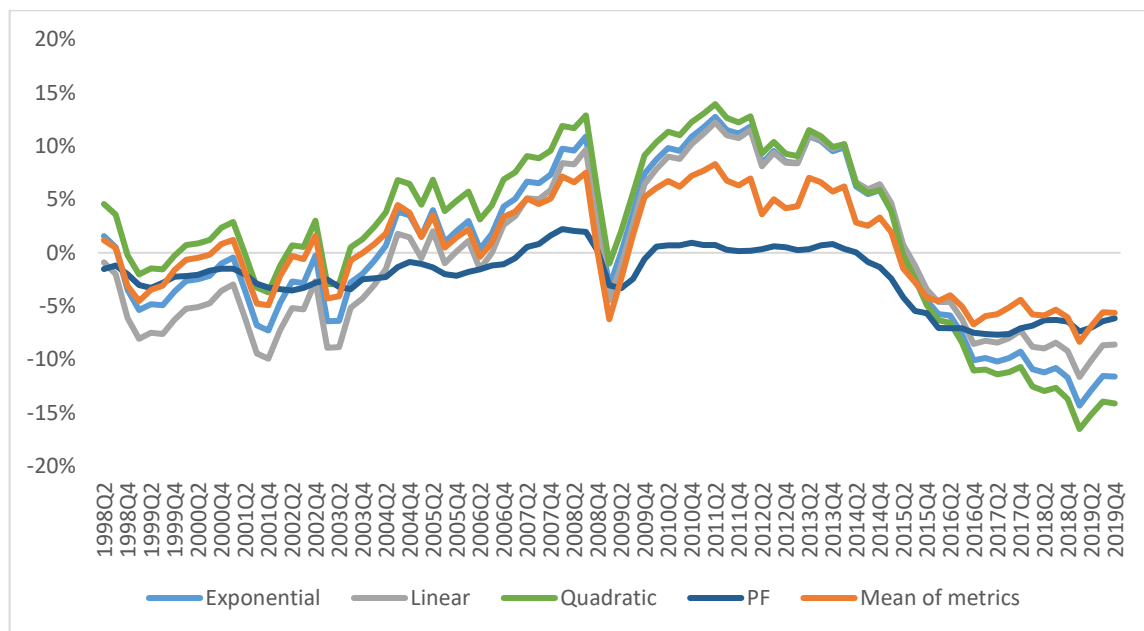


Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

### 3.2.2. Using Mean of Metrics and Production Function

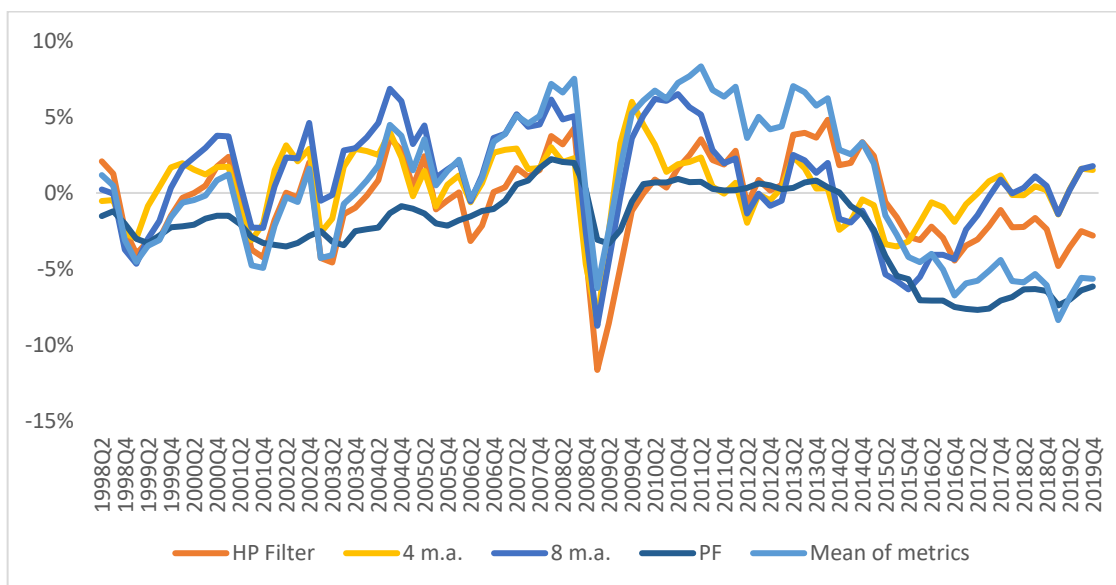
Graphs 11 and 12 show all the calculated gaps. Graph 11 shows the gaps with a trend towards lower rates and Graph 12 shows the gaps with a trend towards higher rates. Production Function and mean of metrics series are placed in both. The more stable role of estimation through the Production Function appears in both graphs.

**Graph 11 – Output gap using Production Function and linear, quadratic and exponential trends**



Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

**Graph 12 – Output gap using Production Function, HP Filter and moving averages of 4 and 8 quarters**



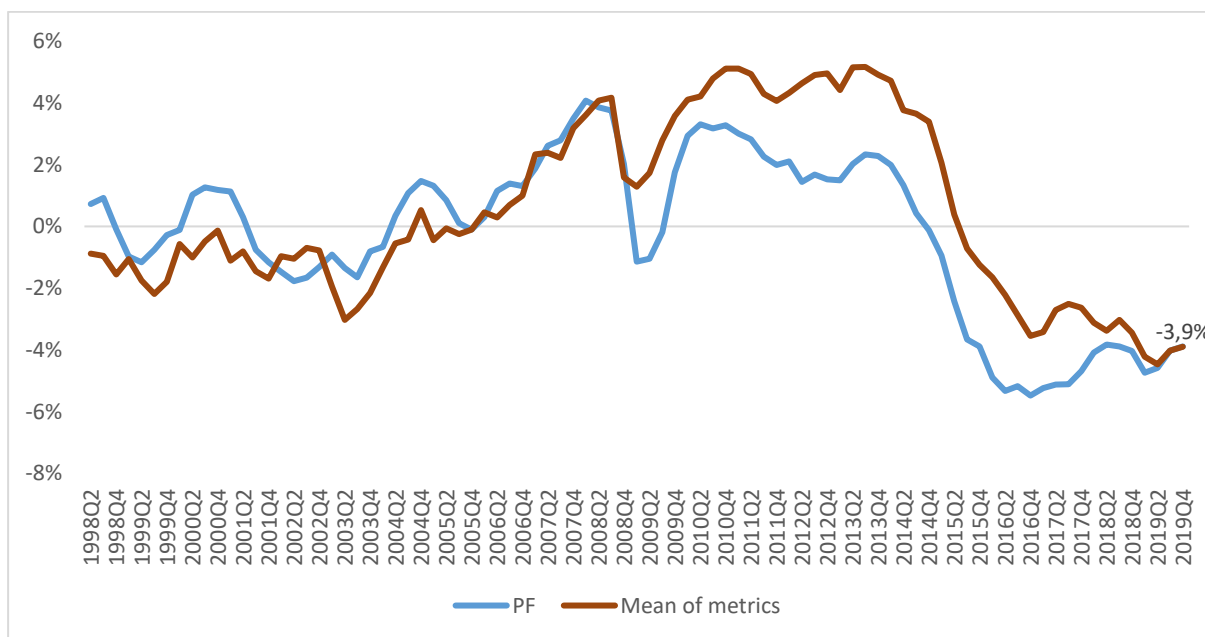
Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

### 3.3 Results for Services<sup>‡</sup>

#### 3.3.1. Using Production Function

The output gap for Services through Production Function and through mean of metrics presented a result of -3.9% in the fourth quarter of 2019.

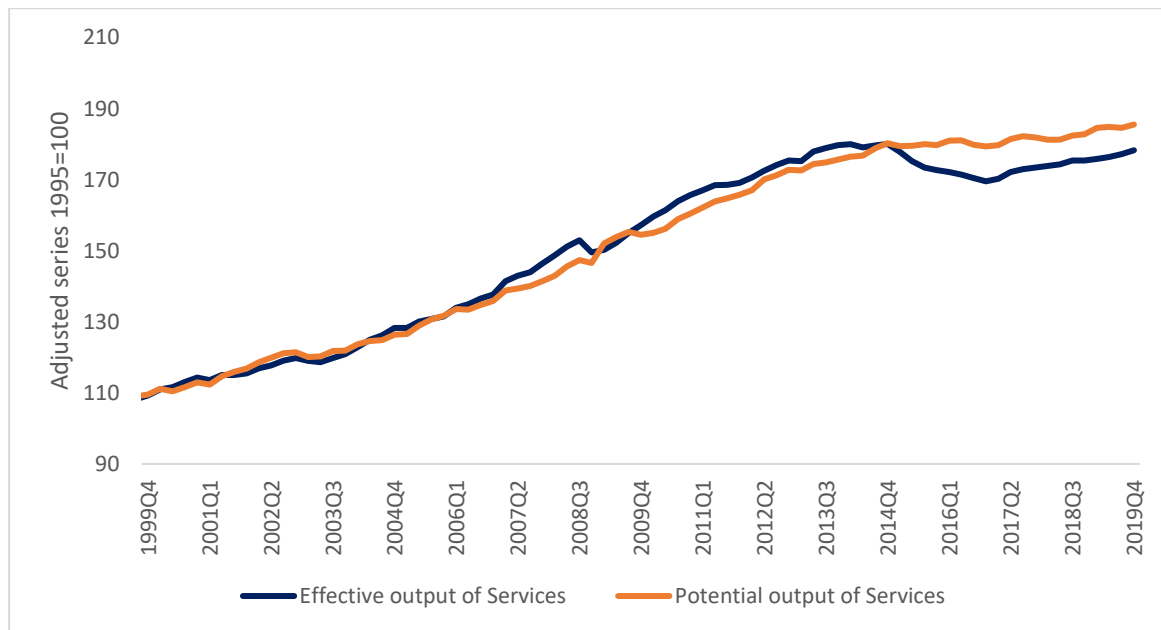
**Graph 13 – Output gap for Services**



Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

<sup>‡</sup> Services, for this paper, according to the classification of the Quarterly Brazilian National Accounts, includes commerce, transports, information services, other services; it excludes financing, public services and rents.

**Graph 14 – Effective and potential output for Services – Production Function**

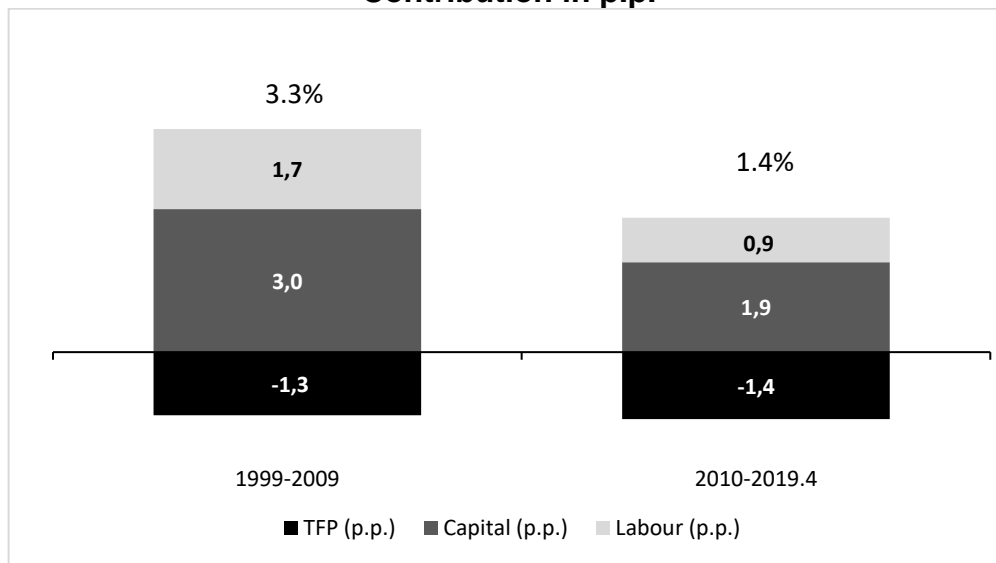


Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

Graphs 13 and 14 above show the Services sector operating with positive gaps for most of the series. This was particularly relevant in the period from 2010 to 2014, when the sector pressured inflation.

Analysing the decomposition of effective output growth in the Services sector, distributed by the decade, it is possible to see that in the first decade, potential output grew by an average of 3.3% per year, with a positive contribution from capital and labour input and a negative contribution from TFP. In the second decade of analysis, effective output grew 1.4% per year, on average, with contributions in the same proportions as the previous decade.

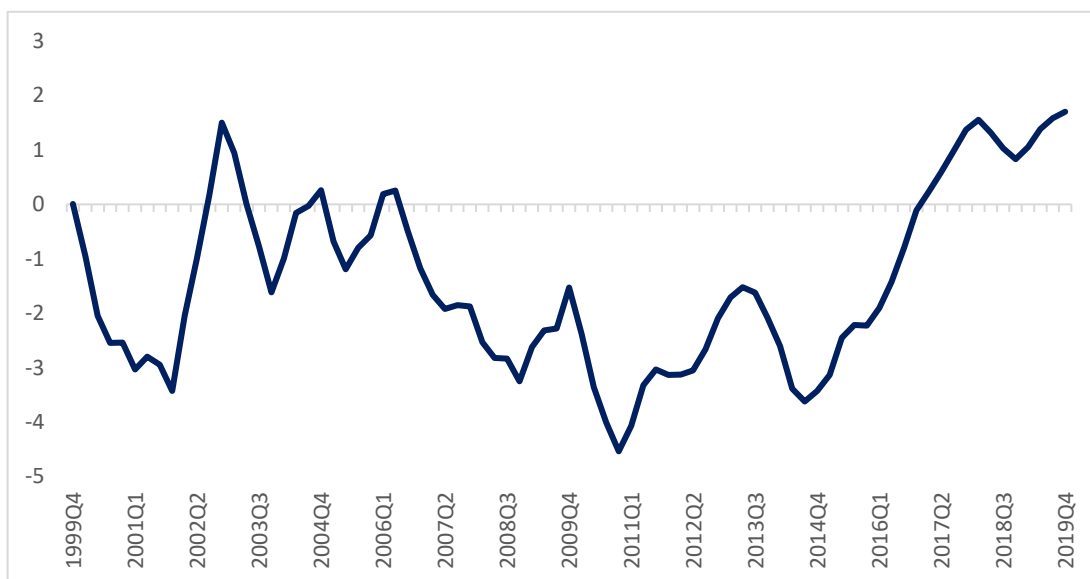
**Graph 15 – Breakdown of effective GDP growth in Services – Annual means – Contribution in p.p.**



Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

Graph 16 below shows that the quarterly evolution of TFP in Services operated negatively for most years. Only recently, since 2017, has it started presenting positive rates, and, in the accumulated rate for 4 quarters, in the fourth quarter of 2019, it presented growth of 1.7%.

**Graph 16 – TFP – Growth accumulated in 4 quarters**

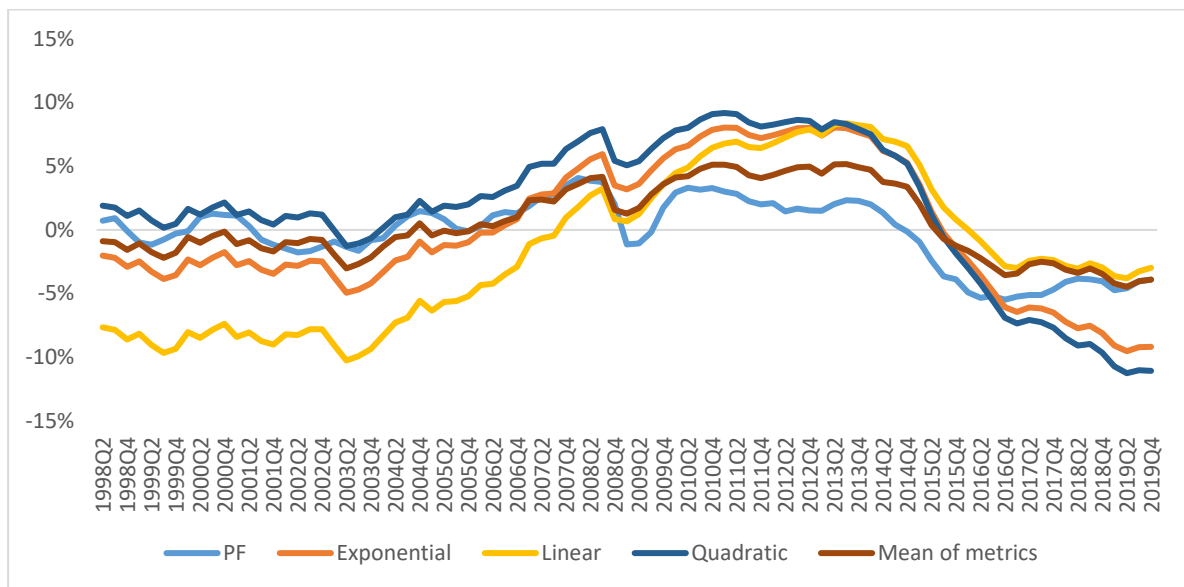


Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

### 3.3.2. Using Mean of Metrics and Production Function

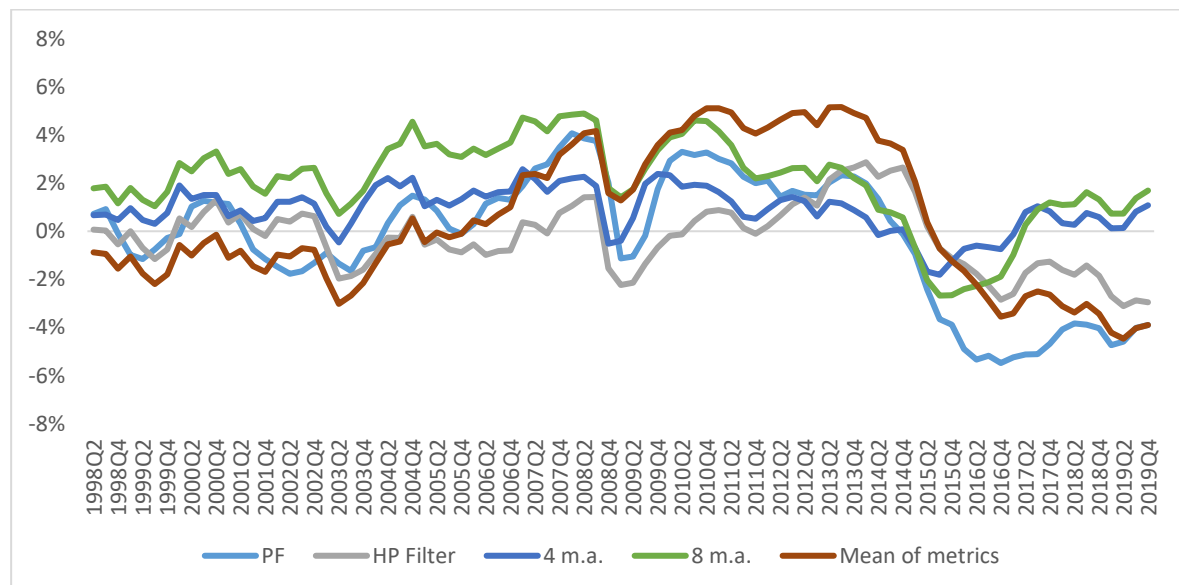
Graphs 17 and 18 below exemplify how the result of mean of metrics is a good approximation of the Production Function result, attenuating discrepancies in the results with high and low biases of statistical metrics.

**Graph 17 – Output gap for Services through Production Function and statistical metrics**



Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

**Graph 18 – Output gap through Production Function and statistical metrics**



Primary source: IBGE, Cunha (2017). Authors elaboration (2020).

## 4. Conclusion

The output gap is an important variable for economic analysis, despite its estimation possibly presenting very different results, depending on the adopted methodology. This study presented potential output for the economy as a whole, Industry, and the Services sector, using various approaches to eliminate biases characteristic of each individual metric.

All the methodologies present certain disadvantages, but the Production Function approach manages to more efficiently incorporate possible changes to the economy in its structure. As a variable that is difficult to estimate accurately, it is important to stress that the choice of the Production Function is not exempt from criticism, and as such, it is important that studies on the subject continue to constantly improve.

Analysis of gap results demonstrated how its evolution impacts business cycles in Brazil. Currently, this analysis provides additional information to the examination of the case of Brazil, in which the economy remains stifled. The country is going through a fiscal crisis, with a gross debt/GDP of approximately 80% and an output gap that remains wide even three years after the last recession.

Analysis of the gap in activities also provides relevant information that assists in understanding the movements in the gap of the economy as a whole, as it enables disaggregated analysis of the economy, making it possible to evaluate which activity is most deficient.

The output gap is also particularly useful for evaluation of a possible return to inflation, thereby guiding monetary policy.

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