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Rafael Tiecher Cusinato, André Minella and Sabino da Silva Pôrto Júnior
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Phones: +55 (61) 3414-3710 and 3414-3565

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Output Gap and GDP in Brazil: a real-time data analysis^{*}

Rafael Tiecher Cusinato^{**}
André Minella^{***}
Sabino da Silva Pôrto Júnior^{****}

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Abstract

Economic agents make decisions using real-time data. However, recent literature has shown that several economic activity measures go through important revisions over time, impairing the reliability of real-time data. We organize a real-time data set for Brazil's GDP, and assess the revisions of both the GDP growth and the output gap. We show that GDP growth revisions are substantial, with a 0.7 p.p. mean absolute revision for the quarter-over-quarter growth, although the revisions become less important for four-quarter changes. To assess output gap revisions, we use four methods to estimate the output gap: Hodrick-Prescott filter, linear trend, quadratic trend, and Harvey-Clark model of unobserved components. The output gap revisions are substantial in all methods, with mean absolute revisions between 0.6 p.p. and 2.3 p.p. In three out of the four methods, the revisions implied changes in the output gap sign in 30 percent or more of the cases. In general, both the GDP data revision and the sample increase are relevant sources of output gap revisions.

Keywords: Real-time data; Output gap; Gross Domestic Product; Business cycle; Brazil.

JEL classification: C82; E32.

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^{**} Research Department, Central Bank of Brazil. Email: rafael.cusinato@bcb.gov.br (corresponding author).

^{***} Research Department, Central Bank of Brazil. Email: andre.minella@bcb.gov.br.

^{****} Graduate Program in Economics, Federal University of Rio Grande do Sul (UFRGS). Email: sabino@ppge.ufrgs.br.

1. Introduction

The recent literature on real-time data analysis has shown that the differences between the data values as initially released and those after undergoing a revision are important. Revisions are a natural part of the data production — as time goes by, the available information set is enlarged, seasonal factors are reestimated, and methodological revisions are implemented. Thus, data usually become more precise over time. The problem is that, in general, agents need to make decisions using real-time data, without benefiting from data revisions. Several authors have studied the features of data revisions. If the revisions are relatively large, the capacity of non-revised series to help decision-making may be limited.

The Gross Domestic Product (GDP) and the output gap are among the most important variables that agents take into account when making decisions. They are used in decisions of consumption, real and financial investments, and, in particular, monetary policy. Although the proper conduct of monetary policy requires a large information set on the state of the economy, the GDP and the output gap are the main economic measures considered. GDP is the major information on the economic activity, and the output gap is a key concept in monetary policy decisions as it allows us to infer about the actual versus potential economic growth. For instance, a positive output gap may call for a monetary policy reaction. This relationship is also found in the literature by means of monetary policy rules, such as the Taylor rule.

However, the recent literature on real-time data has shown the presence of important revisions in the GDP and the output gap data. Croshore and Stark (2000, 2001) organized a real-time data set for the U.S. GDP/GNP, and found relevant growth revisions. Orphanides and van Norden (2002) constructed several historical series for the output gap using real-time data for the U.S. and estimated numerous revision indicators. They show *inter alia* that *ex post* revisions of the output gap have the same magnitude as the own estimated output gap values. The authors suggest that the output gap estimates in real time tend to be unreliable and should be used with great caution.

Similar studies have been conducted for other countries. Cayen and van Norden (2004) analyzed the Canadian GDP growth and found out relevant revisions. Palis, Ramos and Robitaille (2004) found that Brazil's GDP revisions are relatively large when compared to developed economies. In the case of output gap revisions, Cayen and van Norden (2005) and Bernhardsen et al. (2004, 2005) studied the economies of Canada and Norway, respectively. Both studies found that the revision indicators for the output gap are even more unfavorable than those for the U.S. economy. The three works that analyzed the output gap concluded that both GDP data revisions and the low precision of the end-of-sample estimates of the potential output have a relevant contribution for the explanation of the revisions of the output gap.

In this paper, we organize a real-time data set for Brazil's GDP. The data set is comprised of quarterly 51 series, containing the GDP data releases between 1996Q1 and 2008Q2.¹ The first data point in each series refers to the first quarter of 1990. Using this data set, we investigate the behavior of the revisions of GDP growth² and output gap estimates, obtained using four methods: Hodrick-Prescott (HP) filter, linear trend (LT), quadratic trend (QT), and the Harvey-Clark model of unobserved components (HC).

Assuming that our last available data series (referring to 2008Q2) is the best available estimate, we calculate several indicators about the revisions of both GDP growth and the output gap. Given the assumption that the revisions improve the estimates, part of the measurement error of the GDP and output gap is corrected by means of the revisions. In the case of the output gap, we decompose the revisions into two parts: those stemming from the GDP data revisions, and those arising from the inclusion of new observations in the sample.

¹ With the implementation of a methodological change in Brazil's GDP estimation, two series referring to 2006Q4 were released. One is estimated with the previous methodology, and the other with the new one.

² The study by Palis, Ramos and Robitaille (2004) on Brazil's GDP data revisions used the releases for data from 1994Q2 through 2001Q4, focusing on the sequence of revisions. They analyzed *inter alia* some revision indicators for the GDP: mean, absolute mean, and root mean square of the revisions. In our work, besides using a larger and more recent sample, we estimate several additional indicators and also assess the revisions of output gap estimates.

This paper aims at investigating the relevance of data revisions and assessing whether the findings on real-time data from the international literature apply to Brazil. We found that the revisions of GDP growth are substantial — a 0.7 percentage point (p.p.) mean absolute revision of the quarter-over-quarter growth rate — although those revisions become less important as we increase the aggregation period (for instance, four-quarter growth). Likewise, the output gap estimated using any of the detrending methods went under substantial revisions, although the revision indicators are, in general, less unfavorable when compared to those in international studies. The mean absolute revision of the different output gaps stood between 0.6 p.p. and 2.3 p.p. In three out of the four methods analyzed, the revision implied changes in the output gap sign in 30 percent or more of the time, and the magnitude of the revision was higher than the own magnitude of the gap in approximately 50 percent or more of the time. In general, both the GDP data revision and the sample size increase were relevant sources of output gap revisions.

The paper is organized as follows. Section 2 reviews briefly the literature and the concepts used in real-time data analysis. Section 3 clarifies some issues involved in the development of the real-time GDP data set, and analyzes the GDP growth revisions. The following section presents the methods used to estimate the output gap, the methodology to decompose the output gap revisions, and the revisions analysis. Section 5 concludes the paper.

2. Real-time data

The literature on real-time data is related to analyses for which data revisions are relevant or the moment when the data are released is important. The studies have investigated the properties of data revisions, and the impact of data revisions on the macroeconomic research, monetary policy and economic forecasts.

Diebold and Rudebush (1991), for instance, present an example that illustrates the importance of data revision. They show that a leading indicator of industrial production calculated with real-time data performed significantly worse than when estimated with revised data.

Although the literature on real-time data appeared initially in the 1950s, it has been developed mainly after the construction of a large real-time data set for the U.S. economy by Dean Croushore and Tom Stark in mid-1990s. The data set was put available on the internet in 1999,³ and is still updated by cooperation between the Federal Reserve Bank of Philadelphia and the University of Richmond.

The main issue in this literature is the following: Are data revisions large enough in economic terms to be worrisome?⁴ Data revisions pose some difficulties for the analysis of forecast and monetary policy. For example, using the last available data set may be inadequate to compare forecasts coming from a new model with those made in real time. In this case, while the forecasts in real time were made with non-revised data, the new model forecasts have the benefits of using revised data, probably more precise one. Another example refers to the difficulties emerged for policymakers because their decisions use data that may not reflect the true state of the economy.

The presence of data revisions is a fact and should not be understood as a criticism of the work of the institutions that produce those data. Basically, there are three reasons why data are revised over time: i) the information set available to estimate the data increases, allowing a better variable estimate; ii) seasonal factors (when seasonal adjustment is done) are reestimated, changing the historical series; and iii) in order to improve the data quality, changes in the estimation methodology are undertaken periodically, possibly resulting in a new historical series.

In fact, the institutions that generate data face a trade-off between the speed of data release and data precision. On one hand, the institution can produce better data if it waits for a larger information set; on the other hand, economic agents and policy makers, which need to make decisions, demand data available in a timely way.

Real-time data can be defined as the data as they existed prior to subsequent revisions.⁵ Following Croushore and Stark (2000, 2001), we use the term “vintage” to

³ <http://www.philadelphiafed.org/research-and-data/real-time-center/real-time-data/>.

⁴ See Croushore (2008).

⁵ See Stark (2002).

designate the information set available for a variable on a specific date. In other words, it is the last available series, with the most recent revision up to that corresponding moment. The collection of those vintages is called the “real-time data set”.

In order to illustrate those concepts, Table 1 shows a real-time data set for Brazil’s GDP (seasonally adjusted chain-weighted series). The second column (vintage 2007Q1) presents the data available for economic agents when the 2007Q1 figure was released by the first time; the third column (vintage 2007Q2), in turn, records the data available when the 2007Q2 figure was released by the first time; and so forth. Note that all vintages start at the same period — in this case, in the first quarter of 2005. The data series in each column provides the most recent historical series available at a specific moment. On other hand, taking the data corresponding to each row, we can observe how a particular data has been revised. For instance, 2007Q1 figure was initially released as 134.80 and, one quarter later, revised to 135.00. Five quarters after the initial release, in the 2008Q2 vintage, the number became 135.40.

Table 1
Real-Time Data Set for the GDP (quarterly seasonally adjusted data - index number)

Period	Vintage					
	2007Q1	2007Q2	2007Q3	2007Q4	2008Q1	2008Q2
2005Q1	124.60	124.60	124.80	124.80	124.80	124.90
2005Q2	126.80	126.80	127.70	127.80	127.80	127.60
2005Q3	126.70	126.70	126.60	126.70	126.70	126.70
2005Q4	127.80	127.70	127.70	127.60	127.60	127.60
2006Q1	129.40	129.50	129.70	129.50	129.50	129.70
2006Q2	128.90	128.80	129.90	130.00	130.00	129.80
2006Q3	132.40	132.40	132.20	132.30	132.30	132.30
2006Q4	133.80	133.80	134.00	133.90	133.90	134.00
2007Q1	134.80	135.00	135.50	135.20	135.20	135.40
2007Q2		136.10	137.30	137.30	137.30	137.10
2007Q3			139.60	139.80	139.80	139.60
2007Q4				142.00	142.00	142.20
2008Q1					143.00	143.30
2008Q2						145.60

Source: IBGE (See Section 3.1).

The lower diagonal in Table 1, reproduced in column A of Table 2, is called the *real-time data series*. It contains the data series as they were initially calculated. Note that it starts in the quarter corresponding to the first vintage and ends in the quarter corresponding to the last vintage. Note also that this series contains one data point of each vintage. Column B of Table 2, in turn, records what is usually called the *final data series*. The data refers to the same period as that of the real-time data series, but the data are the most recent ones available at the moment of the research. Thus, all data points of this series come from the last vintage (in this case, the 2008Q2 vintage). In column C, we show the data revision series, which is obtained as the difference between the final and the real-time data series. Therefore, the data revision series reveals the total magnitude of the data revision, using as references the first vintage in which the data point was calculated and the last available vintage.

Table 2
Real-Time, Final and Data Revision Series
Seasonally adjusted GDP (index number)

Period	Real Time (A)	Final (B)	Data revision (C)=B-A
2007Q1	134.80	135.40	0.60
2007Q2	136.10	137.10	1.00
2007Q3	139.60	139.60	0.00
2007Q4	142.00	142.20	0.20
2008Q1	143.00	143.30	0.30
2008Q2	145.60	145.60	0.00

Source: IBGE (See Section 3.1).

3. Gross Domestic Product

3.1. *Developing a real-time GDP data set*

The first step of this paper was to organize a real-time GDP data set for Brazil. We use seasonally adjusted quarterly data, starting in 1990Q1. The first vintage refers to 1996Q1, and the last one to 2008Q2. Because of the methodological change in the GDP released in 2007, there are two vintages referring to 2006Q4 – one using the previous

methodology and the other using the new one (both released in March 2007). The data set has been developed using the publications of the National Institute of Geography and Statistics (IBGE) as the source.⁶

In the specific case of 2006Q4, the standard procedure was to use the vintage calculated with the new methodology, unless otherwise indicated. We make this decision because we consider that the information conveyed by the vintage estimated with the new methodology is supposed to be more relevant in real time for economic agents, when compared to that contained in the vintage estimated with the previous methodology, since the methodological change meant an improvement in GDP calculation.

When the data series of a vintage does not go back to 1990Q1, we follow the procedure employed by Cayen and van Norden (2004, 2005). Say the first data point of vintage n refers to period t . The data information about the periods previous to period t of that vintage is filled with those of vintage $n-1$, multiplied by the constant $(GDP_{n,t}/GDP_{n-1,t})$, where $GDP_{n,t}$ is the GDP index for period t , according to vintage n . This procedure is equivalent to proceed in such way that, for each data point missing in a vintage, the data is calculated as to keep the GDP percentage growth presented in the last vintage that contained the data.

3.2. GDP revision analysis

Although the real-time GDP data set is in levels, we analyze data revisions about the (real) GDP growth (percentage change with respect to the i -th previous quarter), calculated as follows:⁷

⁶ “Indicadores IBGE – Contas Nacionais Trimestrais e Valores Correntes” (2000Q3 to 2008Q2); “Indicadores IBGE – Produto Interno Bruto Trimestral” (1996Q1 and 1999Q1 to 2000Q2); and “Indicadores IBGE – Produto Interno Bruto” (1996Q2 to 1998Q4). The only exception is the 2006Q4 vintage of the previous methodology, which was obtained from the IBGE data set (SIDRA) when that vintage was the most recent data series and, thus, available electronically.

⁷ We use the logarithm approximation because of its analytical convenience. For example, the GDP growth rate in n -periods can be easily decomposed into n additive terms. To make sure that the

$$\Delta GDP_{n,t} = 100 \cdot \log \left(\frac{GDP_{n,t}}{GDP_{n,t-i}} \right), \quad (1)$$

where $GDP_{n,t}$ is the GDP index for period t according to vintage n , $\Delta GDP_{n,t}$ is the GDP growth for period t according to vintage n , and \log is the natural logarithm.

GDP growth is a variable followed closely by economic agents and policymakers, in particular, by those involved with monetary policy. In general, the latest available GDP data point, referring to the most recent period, is the most relevant one for decision-making. Unfortunately, it is also the one more subject to revisions.⁸

Figure 1 shows the GDP growth rates defined as the “final” figures (taken from the last available vintage) and the real-time ones.⁹ Although the rates are highly correlated, the differences may be substantial. The importance of GDP data revision is clearer in Figure 2, which presents the GDP growth of the first quarter of 1996 as it evolved over the revisions (we choose this quarter because it was released by the first time in the oldest vintage that we have). When the data was initially released (1996Q1 vintage), 1996Q1 GDP growth rate was 0.13 percent. Two quarters later, in the 1996Q3 vintage, the data was revised to -0.10 percent. The peak occurred in the 2000Q2 vintage

approximation was reasonable, we also did the calculations without the approximation, and the results were very similar.

⁸ According to the IBGE (2008, p.44), “the National Accounts of the previous quarter are revised every time there is a new quarter’s release, with the replacement of previous projections by actual data and the introduction of some revision of the data provided by the periodic surveys of the IBGE or other institutions. In the release of the third quarter of each calendar year, a broader revision is conducted, which incorporates the new weights of the annual National Accounts of two years ago, and possibly revisions in some methodological aspects. The previous year and the first and second quarters of the year are recalculated, incorporating the changes in the weights”. Furthermore, according to the IBGE (2008, p.41), the “annual changes estimated using the quarterly series are adjusted to the annual changes estimated by the National Accounts System in the first data release after the release of the annual accounts. The series are adjusted by means of the minimization of the square of the difference between the observed series and the adjusted one, subject to the restriction that the sum of the four quarters of a year, in the adjusted series, is equal to the total annual in the National Accounts System (Denton’s Method)” (authors’ translation).

⁹ See the appendix for the graph of the GDP in level.

(1.27 percent), and the trough in the 2001Q3 vintage (-0.99 percent). In the 2005Q3 vintage, the figure was changed to 0.60 percent and has been kept since then.

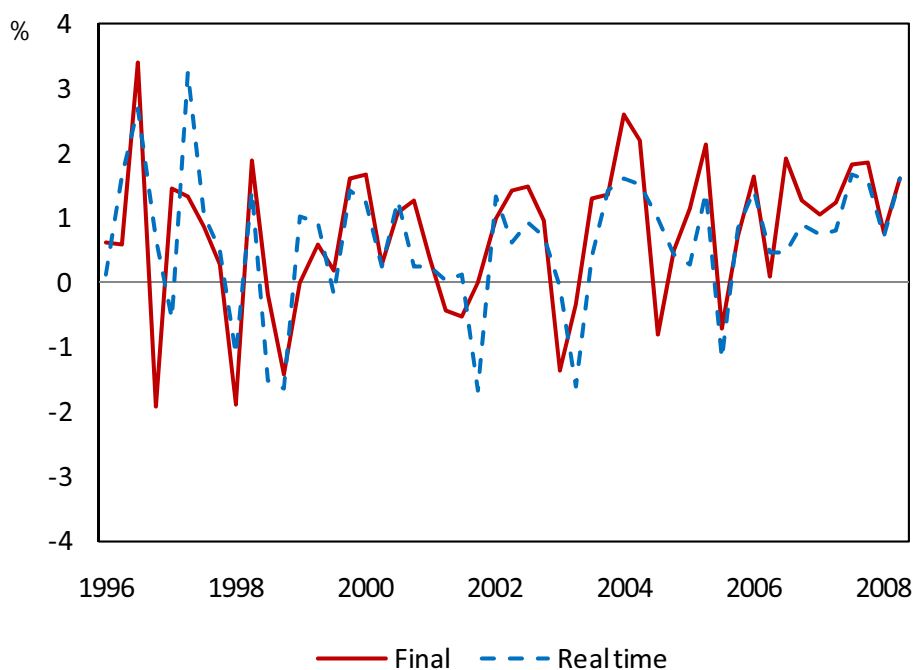


Figure 1 – Final and real-time GDP growth (%)
(quarter-over-quarter)

Figure 2 highlights the magnitude of the GDP growth revisions and the possible impact of data revisions on policy decisions. However, it is still a partial characterization since it refers to the behavior of the values of only one period (1996Q1). Figure 3 presents the relative frequency of GDP revision values. The graph shows that only in 30 percent of the time the revisions were close to zero (between -0.25 p.p. and +0.25 p.p.). In 24 percent of the time, the magnitude of the revision was above 1 p.p. In Figure 4, we can notice all real-time GDP figures (x-axis) and the corresponding final values (y-axis). When the point lies on the 45-degree line, the magnitude of the revision was zero. Observations above the line indicate positive revisions, whereas those below the line represent negative revisions. Furthermore, points in the upper left and lower right quadrants reveal changes in the growth sign after the revisions, which took place in 16 percent of the cases.

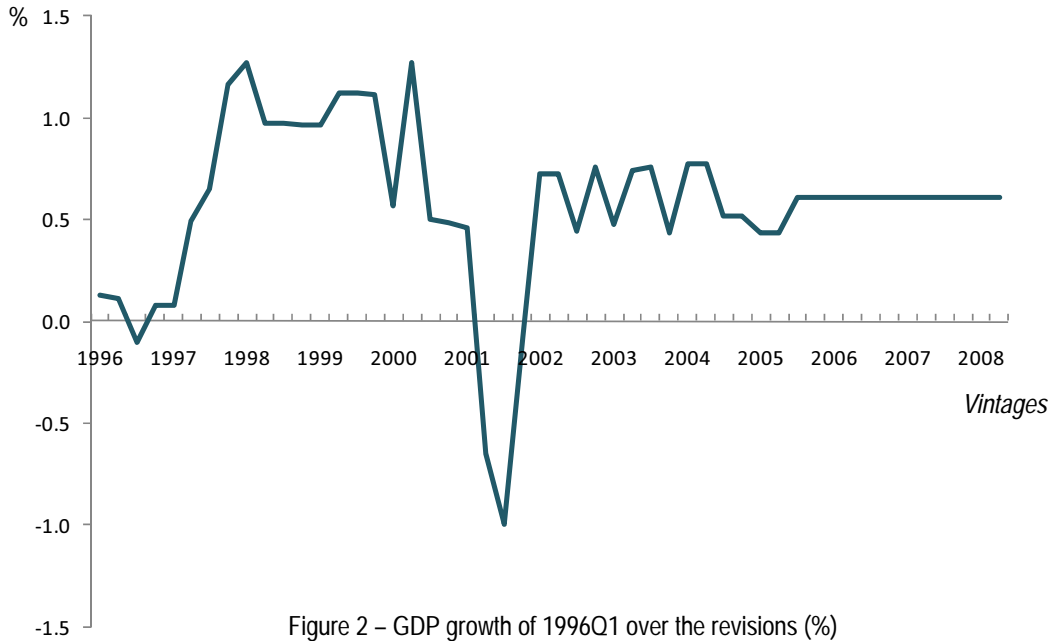


Figure 2 – GDP growth of 1996Q1 over the revisions (%)
(quarter-over-quarter)

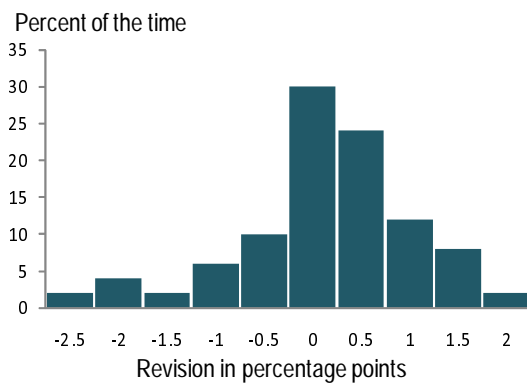


Figure 3 – Relative frequency of the revision of the GDP values

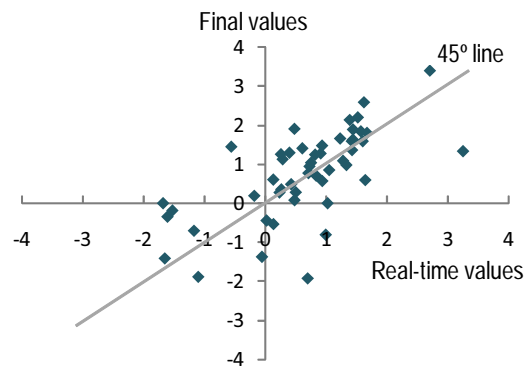


Figure 4 – GDP growth values (real-time versus final)

Table 3 records the statistics for the quarter-over-quarter GDP growth rates series in real time and their corresponding final values as well as the statistics for the data revision series, calculated using the full set of vintages. We can notice that the average growth of real-time GDP was 0.63 percent, whereas that for the final figures stood at 0.75 percent. The average revision was 0.13 p.p. (the highest positive revision was 2.01 p.p., and the highest negative was -2.62 p.p.). The average revision is useful as an indicator of the revision bias, but it is limited as an indicator of the magnitude of the revisions since negative revisions offset positive ones and vice-versa.

Table 3
GDP Growth
(Quarter-on-quarter % change) - 1996Q1-2008Q2

Data	Mean	Standard Deviation	Minimum Value	Maximum Value
Real Time	0.63	1.04	-1.68	3.24
Final	0.75	1.12	-1.93	3.40
Revision	0.13	0.89	-2.62	2.01

Notes: Quarterly seasonally adjusted GDP series.
Due to rounding off, the sum of the means of real-time and revision series is different from the final series mean.

Table 4 records some additional revision indicators. Two of them are especially suitable to capture the magnitude of the revisions: the mean absolute revision (MAR) and the root mean square revision (RMSR). We can notice that the mean absolute revision was 0.67 p.p. In absolute terms, this means that, on average, the quarterly GDP growth was revised in 0.67 p.p. above or below the value initially released. The RMSR indicator is similar to the MAR, but penalizes more strongly revisions of larger magnitude. According to Table 4, RMSR was 0.89 p.p.¹⁰

Table 4
Revision indicators of the GDP growth
(Quarter-on-quarter % change) - 1996Q1-2008Q2

Mean Revision	MAR	RMSR	CORR	N/S	OPSIGN	FRLA	AR
0.13	0.67	0.89	0.67	0.79	0.16	0.26	-0.34

Notes: Quarterly seasonally adjusted GDP series.
MAR is the mean absolute revision.
RMSR is the root mean square revision.
CORR is the correlation between real-time and final GDP growth.
N/S is a proxy for the noise-to-signal ratio (obtained by the ratio of the RMSR to the standard deviation of the final GDP growth).
OPSIGN is the frequency in which real-time and final GDP growth estimates have opposite signs.
FRLA is the frequency with which the absolute value of the revision is larger than the absolute value of the final GDP growth.
AR is the first-order serial correlation of the revision series.

Besides, the two series have a correlation of 0.67, implying that the real-time series explains 44 percent of the variance of the final series. Table 4 also presents the N/S, OPSIGN, FRLA and AR indicators. N/S is a proxy for the noise-to-signal ratio,

¹⁰ Palis, Ramos and Robitaille (2004) found, for Brazil's GDP growth between 1994Q2 and 2001Q4, an average revision of 0.13, a MAR of 0.88, and a RMSR of 1.11.

obtained by the ratio of the RMSR to the standard deviation of the GDP final estimate. Therefore, this measure captures the magnitude of the revisions in relation to the standard deviation of the final series. The N/S value is 0.79, meaning that the magnitude of the revisions is not very different from the series variability.

OPSIGN is the frequency in which real-time GDP growth has the opposite sign to that of the final growth. Table 4 records an OPSIGN of 0.16, i.e. in 16 percent of the cases, the GDP growth data was revised such that its sign was changed. In turn, FRLA is the frequency in which the revision of GDP growth is higher than the final GDP growth, both in absolute values. Table 4 records an FRLA of 0.26, implying that the magnitude of the revision is greater than the magnitude of the final data in 26 percent of the cases.

The revision indicators point that the GDP growth revisions are substantial. However, there is an important mitigating factor: the first-order serial correlation (AR) of the revision series is negative: -0.34. This implies that positive revisions of a quarter are usually followed by negative revisions in the following quarter and vice-versa. Therefore, if we aggregate the revision series, for instance, in annual periods, the revisions will tend to be less important.

In order to check that, we also estimate the revisions of the growth rate of the GDP, calculated comparing the GDP of quarter i to that in i -previous quarter. In other words, we compare the current quarterly GDP to that up to four quarters ago. As we can see in Table 5, both the mean absolute revision per quarter (MAR/q) and the root mean square revision per quarter (RMSR/q), expressed in percentage points per quarter, decrease as the aggregation period increases.¹¹ Furthermore, there is a reduction in the noise-to-signal ratio and a rise in the correlation between real-time and final GDP series. Thus, we can conclude that GDP revisions, although still relevant, become less important when the aggregation period increases. We should stress, however, that there is no significant improvement in the OPSIGN and FRLA indicators.

¹¹ MAR/q corresponds to the MAR divided by the number of associated quarters, and RMSR/q corresponds to the RMSR divided by the number of associated quarters.

Table 5
Revision indicators of the GDP growth
(Quarterly GDP compared with the i -th previous quarter) - 1996Q1-2008Q2

GDP growth rate in	Mean Revision/q	MAR/q	RMSR/q	AR	N/S	CORR	OPSIGN	FRLA
1 quarter	0.13	0.67	0.89	-0.34	0.79	0.67	0.16	0.26
2 quarters	0.07	0.41	0.50	0.14	0.64	0.80	0.18	0.26
3 quarters	0.07	0.32	0.39	0.11	0.62	0.82	0.10	0.30
4 quarters	0.08	0.23	0.29	0.42	0.52	0.89	0.16	0.22

Notes: Quarterly seasonally adjusted GDP series.

Mean revision/q is the mean revision divided by the number of quarters under analysis.

MAR/q is the mean absolute revision divided by the number of quarters under analysis.

RMSR/q is the root mean square revision divided by the number of quarters under analysis.

AR is the first-order serial correlation of the revision series.

N/S is a proxy for the noise-to-signal ratio (obtained by the ratio of the RMSR to the standard deviation of the final GDP growth).

CORR is the correlation between real-time and final GDP growth.

OPSIGN is the frequency in which real-time and final GDP growth estimates have opposite signs.

FRLA is the frequency with which the absolute value of the revision is larger than the absolute value of the final GDP growth.

Alternatively, we can assess the effect of the increase in the aggregation period by means of the growth rate of average GDP over i quarters compared to the average over i quarters before. Mathematically,¹²

$$\Delta GDP_{n,t} = 100 \cdot \log\left(\frac{\sum_{j=0}^{i-1} GDP_{n,t-j}}{\sum_{j=0}^{i-1} GDP_{n,t-i-j}}\right). \quad (2)$$

In this case, it is reasonable to expect an improvement in the revision indicators as the aggregation period increases. When this measure is calculated in real time, only one GDP data point in the numerator did not go through any revision, and the denominator has data points that went through revision more times than the data point in the denominator of identity (1). In fact, Table 6 shows that this phenomenon does occur. There is a strong reduction in the MAR/q and RMSR/q indicators as the aggregation period rises. The mean absolute revision of the four-quarter GDP growth is 0.16 per quarter, corresponding to 0.64 in annual terms. Besides, there is a considerable improvement in the OPSIGN and FRLA indicators.

¹² Note that, when $i=1$, equations (1) and (2) are equivalent to each other.

Table 6
Revision indicators of the GDP growth
(*i*-period average GDP compared with the previous period) - 1996Q1-2008Q2

Average GDP in	Mean Revision/q	MAR/q	RMSR/q	AR	N/S	CORR	OPSIGN	FRLA
1 quarter	0.13	0.67	0.89	-0.34	0.79	0.67	0.16	0.26
2 quarters	0.05	0.31	0.39	0.30	0.58	0.84	0.10	0.24
3 quarters	0.06	0.21	0.26	0.65	0.48	0.90	0.12	0.20
4 quarters	0.04	0.16	0.21	0.82	0.48	0.89	0.06	0.14

Notes: Quarterly seasonally adjusted GDP series.

Mean revision/q is the mean revision divided by the number of quarters under analysis.

MAR/q is the mean absolute revision divided by the number of quarters under analysis.

RMSR/q is the root mean square revision divided by the number of quarters under analysis.

AR is the first-order serial correlation of the revision series.

N/S is a *proxy* for the noise-to-signal ratio (obtained by the ratio of the RMSR to the standard deviation of the final GDP growth).

CORR is the correlation between real-time and final GDP growth.

OPSIGN is the frequency in which real-time and final GDP growth estimates have opposite signs.

FRLA is the frequency with which the absolute value of the revision is larger than the absolute value of the final GDP growth.

We should pay attention to the change in methodology introduced by the IBGE as of the 2006Q4 vintage.¹³ The issue is whether that change is a relevant source of revisions.

In Table 7, we seek to isolate the effect of the methodological change on the quarter-over-quarter GDP growth revisions from 1996Q1 through 2006Q4.¹⁴ The average real-time GDP growth was 0.55 percent per quarter. Using the 2006Q4 vintage with the previous methodology, the average GDP growth stood at 0.61 percent, whereas that with the new methodology was 0.66 percent.

The lower part of Table 7 records a decomposition of the revision of the GDP growth up to 2006Q4. The average revision with the previous methodology was 0.66 p.p. The introduction of the new methodology generated a further average revision of 0.05 p.p., totaling 0.11 p.p. This means that, on average, the introduction of the new methodology increased the GDP growth estimates between 1996Q1 and 2006Q4. The

¹³ The quarterly GDP series also went under other methodological changes in the past. See Palis, Ramos and Robitaille (2004).

¹⁴ In this analysis, real-time GDP growth in 2006Q4 (first line in Table 7) was calculated using the 2006Q4 vintage with the previous methodology.

methodological change generated an additional MAR of 0.52 and an additional RMSR of 0.71, implying a change in the MAR from 0.53 to 0.75, and in the RMSR from 0.73 to 0.97. Thus, those results indicate that, in fact, the methodological change was a relevant source of revisions, although it explains only part of the total revision.

Table 7
GDP growth and methodological change in the 2006Q4 vintage
(Quarter-on-quarter % change) - 1996Q1-2006Q4

	Mean	Standard Deviation	Minimum Value	Maximum Value	CORR	AR	MAR	RMSR
Real Time(*)	0.55	1.07	-1.68	3.24	1.00			
2006Q4 vintage with the previous methodology	0.61	1.02	-1.86	3.13	0.75			
2006Q4 vintage with the new methodology	0.66	1.16	-1.93	3.40	0.62			
Revision decomposition in 2006Q4								
Revision with the previous methodology	0.06	0.74	-2.75	1.61		-0.26	0.53	0.73
Additional revision with the new methodology	0.05	0.72	-1.87	1.84		-0.38	0.52	0.71
Total revision in 2006Q4 with the new methodology	0.11	0.97	-2.62	2.13		-0.40	0.75	0.97

Notes: Quarterly seasonally adjusted GDP series.

CORR is the correlation of real time and final GDP growth.

AR is the first-order serial correlation of the revision series.

MAR is the mean absolute revision.

RMSR is the root mean square revision.

(*) The 2006Q4 real-time GDP growth was computed by using the 2006Q4 vintage referring to the previous methodology.

Table 8 proceeds to a similar exercise but for the year-over-year GDP growth rate (change in the quarterly GDP in relation to the GDP of the same quarter of the previous year). The average revision with the previous methodology was 0.18 p.p. The introduction of the new methodology generated a further average revision of 0.16 p.p., totaling 0.34 p.p. Furthermore, the methodological change led to a further MAR of 0.71 and an additional RMSR of 0.93, implying a change in the MAR from 0.56 to 1.03, and in the RMSR from 0.74 to 1.25. Thus, Table 8 results reinforce the finding that the methodological change was a relevant source of revisions, although it does not preclude the importance of other factors.

Table 8
 GDP growth and methodological change in the 2006Q4 vintage
 (Year-on-year growth rate) - 1996Q1-2006Q4

	Mean	Standard Deviation	Minimum Value	Maximum Value	CORR	AR	MAR	RMSR
Real Time(*)	2.06	2.33	-2.50	6.42	1.00			
2006Q4 vintage with the previous methodology	2.24	2.08	-1.98	6.05	0.95			
2006Q4 vintage with the new methodology	2.40	2.13	-1.96	7.14	0.85			
Revision decomposition in 2006Q4								
Revision with the previous methodology	0.18	0.72	-1.40	1.83		0.11	0.56	0.74
Additional revision with the new methodology	0.16	0.93	-2.58	2.11		0.41	0.71	0.93
Total revision in 2006Q4 with the new methodology	0.34	1.22	-2.57	2.33		0.40	1.03	1.25

Notes: Quarterly seasonally adjusted GDP series.
 CORR is the correlation between real-time and final GDP growth.
 AR is the first-order serial correlation of the revision series.
 MAR is the mean absolute revision.
 RMSR is the root mean square revision.
 (*) The 2006Q4 real time GDP growth was computed by using the 2006Q4 vintage referring to the previous methodology.

To compare the revision indicators of this paper with those found for other countries, we use the results of Table 9 and 10. We should stress that those comparisons do not allow us compare the quality of the data produced by the statistics institutions of different countries. We are measuring the estimate errors that were corrected subsequently (assuming that the revisions improve the estimates) and not the total error of the real-time estimates (we do not know the true errors associated with the final estimates of each country).

Table 9 compares some revision indicators for the Brazilian GDP with those from Cayen and van Norden's (2004) study for Canada. We can note that the revision bias is higher in the Canadian case for two- and four-quarter growth rates. However, the magnitude of the revisions is greater in the Brazilian case (RMSR/q). Besides, the Canadian real-time data series are a little more correlated with the final series than in Brazil. In both cases, the magnitude of the revision becomes less important as the aggregation period increases. Furthermore, for both countries, AR is negative for one-quarter GDP growth and positive for two- and four-quarter growth rates.

Table 9
Revision indicators of the GDP growth
Comparison with Cayen and van Norden (2004) (*)

GDP growth rate in	Mean Revision/q		RMSR/q		AR		CORR	
	Brazil	Canada	Brazil	Canada(^)	Brazil	Canada	Brazil	Canada
1 quarter	0.13	0.13	0.89	0.62	-0.34	-0.21	0.67	0.75
2 quarters	0.07	0.11	0.50	0.39	0.14	0.25	0.80	0.87
4 quarters	0.08	0.11	0.29	0.26	0.42	0.60	0.89	0.92

Notes: Quarterly seasonally adjusted GDP series.

Mean revision/q is the mean revision divided by the number of quarters under analysis.

RMSR/q is the root mean square revision divided by the number of quarters under analysis.

AR is the first-order serial correlation of the revision series.

CORR is the correlation between real-time and final GDP growth.

(*) Period of analysis: Brazil: 1996Q1-2008Q2; Canada: 1972Q1-2003Q4.

(^) Computed in this work by using the means and standard deviations presented in the original work.

Table 10 compares the indicators of mean revision and MAR for Brazil with those analyzed by Ahmad, Bournot and Koechlin (2007) for several countries. We can notice that, in general, the biases are positive, as in the Brazilian case. The MAR in most of the cases is lower than the Brazilian one. The exceptions are Japan, for 1996Q1-2000Q4, and the United Kingdom, for 1982Q1-1993Q4. In spite of the limitations of this type of comparisons, those results point to the importance of analyzing the limits of the use of real-time data in the Brazilian case.

Table 10
Revision indicators of the GDP growth (quarter-on-quarter change)
Comparison with Ahmad, Bournot e Koechlin (2007)

Country	Period	Mean Revision	MAR
Brazil	1996Q1-2008Q2	0.13	0.67
Canada	1996Q1-2000Q4	0.20	0.28
	1980Q1-1993Q4	0.08	0.39
France	1996Q1-2000Q4	0.10	0.27
	1980Q1-1993Q4	0.05	0.29
Germany	1996Q1-2000Q4	-0.08	0.40
	1980Q1-1993Q4	0.05	0.60
Italy	1996Q1-2000Q4	0.13	0.39
	1987Q1-1993Q4	0.10	0.38
Japan	1996Q1-2000Q4	0.22	1.02
	1980Q2-1993Q4	-0.01	0.50
United Kingdom	1996Q1-2000Q4	0.16	0.34
	1982Q1-1993Q4	0.18	0.80
United States	1996Q1-2000Q4	0.06	0.38
	1980Q1-1993Q4	0.04	0.42

Notes: Quarterly seasonally adjusted GDP series.

MAR is the mean absolute revision.

4. Output Gap

The output gap is usually defined as the difference between output (GDP) and the potential output (potential GDP). In practical terms, the output gap is usually obtained by means of methods that estimate the trend, and it is then calculated as the deviation of the output from the trend.¹⁵

4.1. *Methods for detrending output*

We can decompose the output into a trend component (potential output) and a cycle element (output gap):

$$y_t = y_t^* + x_t, \quad (3)$$

where y_t is the logarithm of GDP, y_t^* is the logarithm of the potential output, and x_t is the output gap in period t .

We use four detrending methods: the Hodrick-Prescott (HP) filter, linear trend (LT), quadratic trend (QT), and the Harvey-Clark model of unobserved components (HC).¹⁶

The HP filter, introduced by Hodrick and Prescott (1997),¹⁷ may be the most popular method to obtain the output gap estimates. The potential output component is obtained through the minimization of the following loss function:

¹⁵ This measure is not necessarily consistent with the output gap definition of the new Keynesian theory. In the new Keynesian approach, the output gap is the deviation of the output from the output that would prevail with fully flexible prices and wages. Although theoretically appealing, that definition is much harder to be measured in practical terms. Thus, the use of detrending methods is the most usual way to estimate the output gap.

¹⁶ Note that we do not include the production function-based method. The reason is that the main variables used in this method are the unemployment rate and the rate of capacity utilization. For an application of different methods to estimate the output gap in Brazil, see, for example, Araújo and Guillén (2008).

¹⁷ Although Hodrick and Prescott's article was published in 1997, the related working paper appeared in 1981.

$$L = \sum_{t=1}^T (y_t - y_t^*)^2 + \lambda \sum_{t=2}^{T-1} (\Delta y_{t+1}^* - \Delta y_t^*)^2, \quad (4)$$

where λ is the smoothing parameter and T is the sample size. The parameter λ is a positive number that penalizes the variability of the potential output growth. A change in this parameter affects the sensitivity of the potential output to GDP changes. As $\lambda \rightarrow \infty$, the minimization generates a constant potential output growth (in this case, the HP filter is equivalent to the linear trend method). On the other hand, as $\lambda \rightarrow 0$, the potential output follows fully the GDP (potential output is equal to actual GDP), turning the cyclical component (the output gap) zero. As usual, we use the value suggested by Hodrick and Prescott (1997) for the smoothing parameter, $\lambda=1600$. Once y_t^* is calculated, we can obtain the output gap from equation (3).

The linear trend is the simplest method to obtain the output gap. We estimate the following regression:

$$y_t = \alpha + \beta t + e_t, \quad t = 1, \dots, T. \quad (5)$$

The fitted values of y_t correspond to the estimated potential output, and the residual series corresponds to the output gap series.

The quadratic trend is an extension of the linear trend as it adds a quadratic term. Thus, the procedure is similar to that in the case of the linear trend, except for estimating the following equation instead:

$$y_t = \alpha + \beta_1 t + \beta_2 t^2 + e_t, \quad t = 1, \dots, T. \quad (6)$$

Finally, the Harvey-Clark method, introduced by Harvey (1985) and Clark (1987), uses a model of unobserved components to decompose the GDP into a permanent component (potential output) and a transitory one (output gap):¹⁸

¹⁸ We included the Harvey-Clark method in our analysis because it is probably the most popular detrending method among unobserved-components models. Besides, the choice for the Harvey-Clark method (among a large variety of unobserved-components models) allows us to compare the results with those of the international studies that analyzed output gap revisions. On the other hand, there are

$$y_t = y_t^* + x_t \quad (7)$$

$$y_t^* = \mu_{t-1} + y_{t-1}^* + v_t, \quad v_t \sim i.i.d. N(0, \sigma_v^2) \quad (8)$$

$$\mu_t = \mu_{t-1} + w_t, \quad w_t \sim i.i.d. N(0, \sigma_w^2) \quad (9)$$

$$x_t = \phi_1 x_{t-1} + \phi_2 x_{t-2} + e_t, \quad e_t \sim i.i.d. N(0, \sigma_e^2). \quad (10)$$

Equation (7), which is identical to equation (3), is the decomposition of the GDP into potential output and output gap. Equation (8) assumes that that potential output follows a random walk with drift, and equation (9) assumes that the drift term follows a random walk. By equation (10), the output gap follows an autoregressive process of order two — AR(2). The processes v_t, w_t and e_t are mutually non-correlated. Alternatively, the model can be represented in the following state-space form:

$$y_t = [1 \quad 1 \quad 0 \quad 0] \begin{bmatrix} y_t^* \\ x_t \\ x_{t-1} \\ \mu_t \end{bmatrix} \quad (11)$$

$$\begin{bmatrix} y_t^* \\ x_t \\ x_{t-1} \\ \mu_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & \phi_1 & \phi_2 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} y_{t-1}^* \\ x_{t-1} \\ x_{t-2} \\ \mu_{t-1} \end{bmatrix} + \begin{bmatrix} v_t \\ e_t \\ 0 \\ w_t \end{bmatrix}, \quad (12)$$

where y_t^*, x_t and μ_t are the unobservable variables to be estimated. The variances of the three shocks and the coefficients ϕ_1 and ϕ_2 are the five parameters to be estimated. The model is estimated using maximum likelihood, implemented using the Kalman filter.¹⁹

detrending models of unobserved components that incorporate a Phillips curve in their specifications. However, the choice of one of these methods would not be feasible as the sample size is not sufficient to conduct recursive estimates since we have to disregard data of the high inflation period, previous to the introduction of *Real* in 1994.

¹⁹ The estimations of Harvey-Clark's model were conducted using *Gauss*, adapting a code of Kim and Nelson (1999), which is available on the *internet*: <http://www.econ.washington.edu/user/cnelson/markov/prgmlist.htm>.

4.2. Components of the output gap revisions

Based on Orphanides and van Norden's (2002) methodology, we analyze the behavior of the output gap estimates at the end of the sample and their revisions. To this end, we calculate three groups of output gap estimates: i) final estimates; ii) real-time estimates; and iii) "quasi-real" estimates.

The final estimates of the output gap are conducted with the last vintage of GDP data used in this paper (2008Q2). The resulting series is comprised of final gaps. This is the usual way of estimating output gaps, employed in works that do not take into account the presence of data revision.

We obtain the real-estimates estimates of the output gap in two steps. First, the output gaps are estimated for all available vintages, that is, for each vintage, we estimate the corresponding gap series. In the second step, we take the last observation of each gap series. The resulting series is comprised of the *real-time output gaps*. The series contains, in each quarter, the first output gap estimate that agents could have accessed.²⁰

The total output gap revision in each period is the difference between the final and the real-time gaps. This revision can be decomposed further into two sources: i) GDP data revisions; and ii) increase in the number of periods as time goes by (sample size effect).²¹ To isolate the importance of those sources, we estimate a third group of output gap estimates: quasi-real estimates.

The *quasi-real estimates* of the output gap are calculated using the same sample size of the real-time estimates, but employing final instead of real-time data; so the sample is truncated in each considered period. Initially we estimate the output gap series using final data until 1996Q1; then we estimate a new series using final data up to 1996Q2; and so on, until we estimate the last series using data up to 2008Q2. Subsequently, we take the last observation from each estimated series. The resulting

²⁰ We should stress that the vintage and, therefore, the output gap estimate of quarter t is available for economic agents in quarter $t+1$.

²¹ Part of the effect in both cases is due to the reestimation of seasonal factors.

series consists of quasi-real output gaps. The difference between quasi-real and real-time gaps stems from GDP data revisions since the estimates of the two series in each quarter are conducted with a sample that covers exactly the same period. On the other hand, the difference between the final and quasi-real estimates captures the effect of the sample increase.

Our revision analysis consists basically in measuring the estimate changes as data is revised and the information set rises (i.e., as GDP data about new periods are released). We assume implicitly that revisions improve the output gap estimates. However, it is reasonable to assume that some degree of uncertainty remains in the last vintage of the output gap. This vintage will likely be revised or, even if this were not the case, it will have the methodological limitations of any GDP estimate. Furthermore, even with a perfectly measured GDP, the output gap is an unobservable variable, implying that any estimate conveys a non-negligible degree of uncertainty. Thus, the total revision captures part of the measurement error associated with the output gap estimated using real-time data.

Since our methodology neither associates the revisions with specific applications (forecasting, monetary policy analysis, etc.) nor requires assumptions about the true structure of the economy or about the true data generating process, the results are fairly general. However, we should be cautious and not compare the adequacy of the different methods of calculating the output gap based on the size of the revisions. Assuming that revisions improve the estimates, we are measuring the estimate errors that are subsequently corrected, and not the total error of the estimates in real time.²²

4.3. Analysis of output gap total revisions

Figure 5(a) shows the real-time output gap series for the four considered methods. The shaded area of Figure 5(b) presents, for each time period, the interval in which the estimated output gaps lie. That range can be interpreted as a measure of

²² Suppose that the series based in method A has lower revisions than that from method B. However, it is possible that the final estimates of the former are more imprecise than those from the latter, and thus we cannot conclude that method A is superior to method B.

uncertainty in the sense of “thick modeling”.²³ The four output gap series have strong short-run co-movements. All cross correlations are superior to 0.70, except for that between LT- and QT-based series.

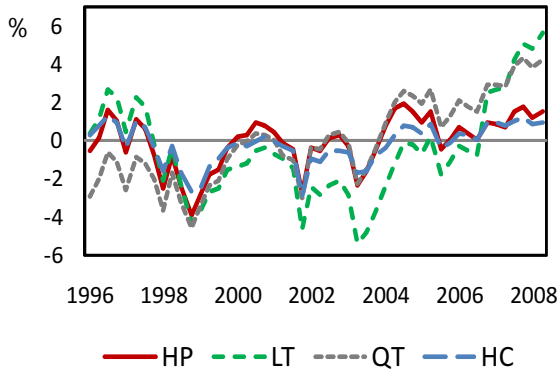


Figure 5 (a) – Real-time output gap

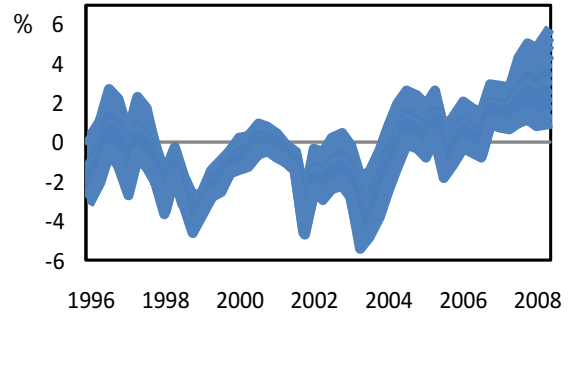


Figure 5 (b) – Real-time output gap – Thick Modeling

Figure 6 presents two graphs that are similar to the previous ones, but recording the final output gap series, estimated using the 2008Q2 vintage. All cross correlations are positive, and their values, except for those involving the Harvey-Clark method, are high.

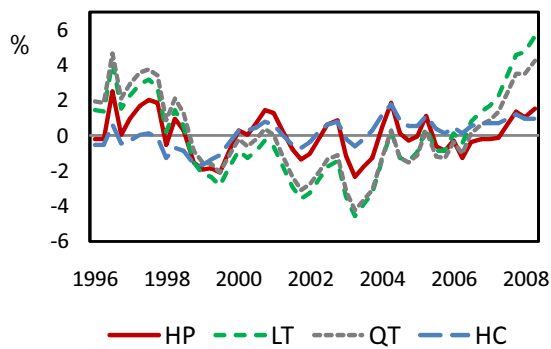


Figure 6 (a) – Final output gap

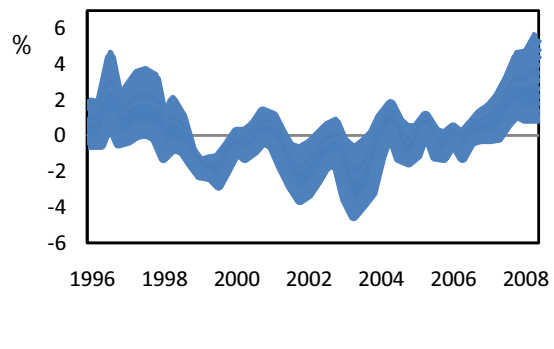


Figure 6 (b) – Final output gap – Thick Modeling

²³ See Granger and Jeon (2004).

The real-time series have important differences with respect to the final ones. Figure 7 compares both series, estimated using the HP filter. The correlation between the series is 0.64. The real-time series have higher variability and, in 30 percent of the cases, the signs of the observations are opposite to those of the final series.²⁴

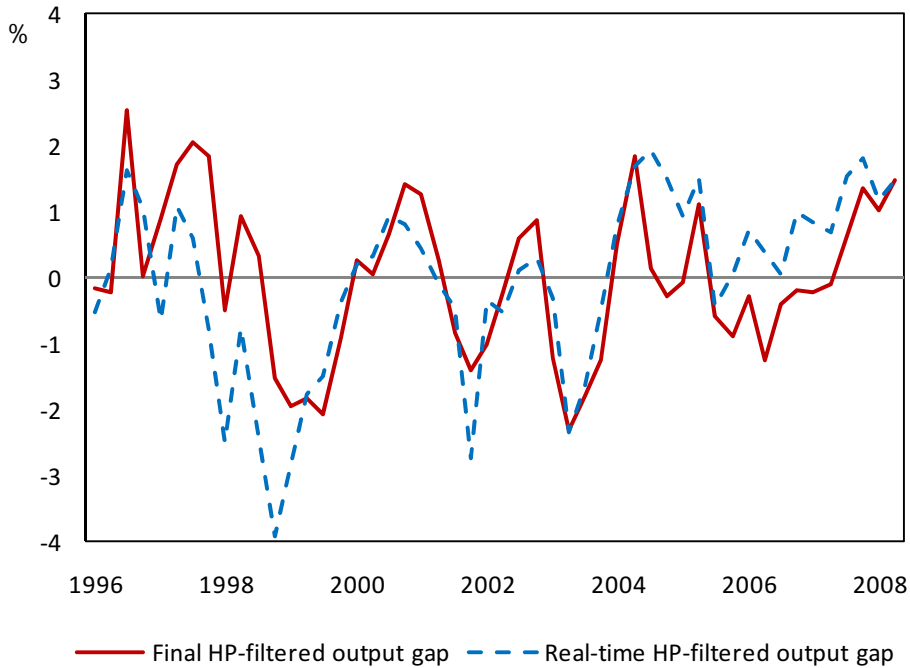


Figure 7 – Final and real-time HP-based output gaps

To illustrate the importance of the output gap revisions, Figure 8 depicts the behavior of HP-based output gap estimates for 1996Q1 over time. When the output gap was initially estimated (with the 1996Q1 vintage), the gap was -0.52 percent of the GDP. In the 1996Q4 vintage, it was revised to the trough of -1.11 percent, and, in the 2001Q1 vintage, it peaked at 0.31 percent. In the 2006Q4 vintage, in turn, it was revised to -0.16 percent, kept constant afterwards. Again, as in the case of the GDP revisions, the figure highlights the magnitude of the revisions.

Figure 9 records the relative frequency of the values of the output gap revisions. It shows that only in 15 percent of the cases the revisions were close to zero (between -0.25 p.p. and +0.25 p.p.). In 32 percent of the time, the magnitude of the

²⁴ See the appendix for graphs analogous to that of Figure 7 for the methods of linear trend, quadratic trend and Harvey-Clark.

revision was greater than 1 p.p. Figure 10 records all HP-based real-time output gaps (x-axis) and the associated final values (y-axis). When the points lie on the 45-degree line, the revisions were zero. Points that are above that line indicate upward revisions, whereas those below, downward revisions. Observations that are in the upper left and lower right quadrants reveal changes in the sign after the revisions, which occurred in 30 percent of the time.²⁵

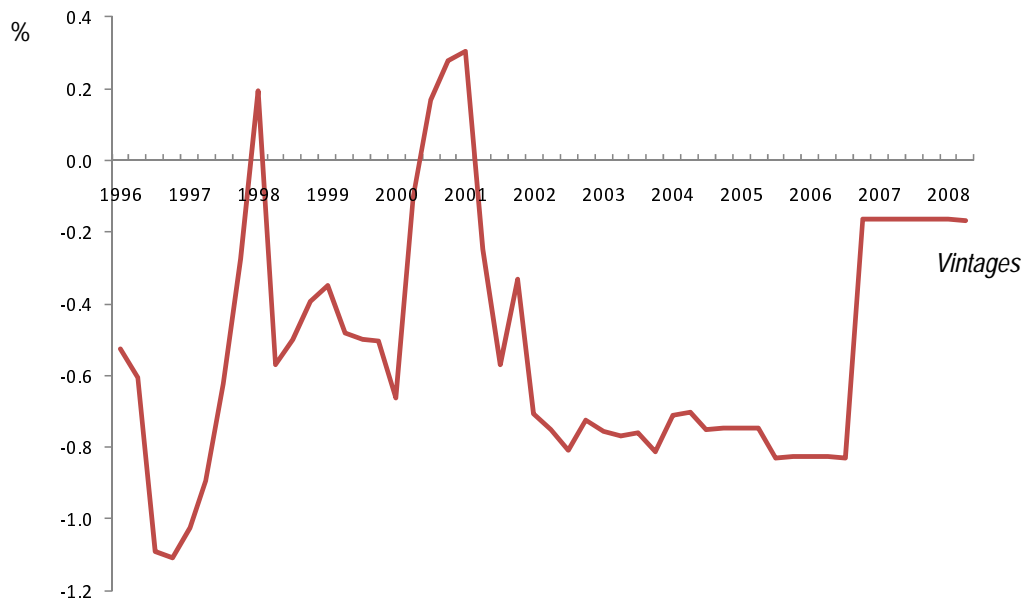


Figure 8 – Output gap (HP filter) of 1996Q1 over the revisions (% of GDP)

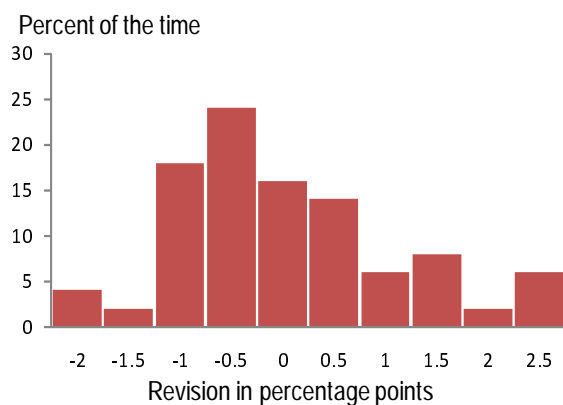


Figure 9 – Relative frequency of the revision of the values of the HP-based output gap

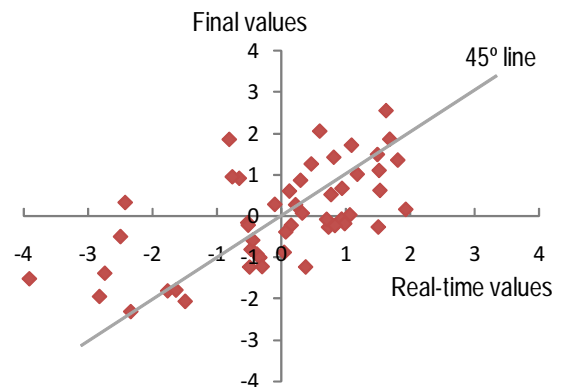


Figure 10 – HP-based output gap values (real-time versus final)

²⁵ See the appendix for graphs analogous to those of Figures 8 to 10 for the other methods.

Table 11 records some descriptive statistics for the series of output gap and their revisions. As expected, the linear trend-based output gap series have greater amplitude and standard deviation than HP-based series does. Since the HP smoothing parameter is $\lambda=1600 < \infty$, potential output follows more closely GDP than in the linear trend case, implying lower variability and amplitude for the resulting output gap series. Furthermore, potential output generated by the Harvey-Clark method was the one that more closely followed the GDP series,²⁶ implying a gap series with lower standard deviation and amplitude. No total mean revision — difference between the averages of final and real-time output gap series — was negative.

Table 11
Output Gap (%)
1996Q1-2008Q2

Method	Mean	Standard Deviation	Minimum Value	Maximum Value
Hodrick-Prescott (HP)				
Real-time	-0.04	1.37	-3.91	1.93
Quasi-real	0.11	1.37	-3.03	3.06
Final	0.01	1.18	-2.32	2.55
Total Revision	0.04	1.09	-1.77	2.75
Linear Trend (LT)				
Real-time	-0.55	2.58	-5.36	5.62
Quasi-real	-0.17	2.45	-4.03	5.62
Final	-0.15	2.45	-4.54	5.62
Total Revision	0.40	1.08	-1.51	2.97
Quadratic Trend (QT)				
Real-time	0.01	2.25	-4.56	4.33
Quasi-real	0.54	2.35	-3.53	4.46
Final	0.01	2.23	-4.26	4.65
Total Revision	0.00	2.80	-3.88	5.52
Harvey-Clark (HC)				
Real-time	-0.19	1.04	-2.89	1.31
Quasi-real	0.13	0.93	-2.09	2.13
Final	0.10	0.77	-1.68	1.78
Total Revision	0.29	0.74	-1.38	2.20

Notes: The data sample for the output gap estimation starts in 1990Q1.
Due to rounding off, the sum of real-time gap and total revision means may be different from final gap mean.

²⁶ Note that, in the case of the real-time and quasi-real series, this claim refers only to the GDP and potential output of the last period of each estimation, since the gap that is included in these series is always the last period's gap of each estimation.

Table 12 shows several revision indicators. The mean revision, also recorded in the previous table, was higher for the LT (0.40 p.p.) and HC (0.29 p.p.) methods. The mean revision was only 0.04 for the HP method, and zero for the QT method. Although high revision mean figures imply substantial magnitude of revisions, low values do not necessarily imply a low magnitude since negative revisions may offset positive revisions and vice-versa. In fact, the mean revision measure is more appropriate to gauge the bias of the revision than its magnitude.

Table 12
Revision Indicators - Output Gap (%)
1996Q1-2008Q2

	Mean Revision	MAR	RMSR	AR	N/S	CORR	OPSIGN	FRLA
Hodrick-Prescott (HP)	0.04	0.84	1.08	0.63	0.92	0.64	0.30	0.46
Linear Trend (LT)	0.40	0.89	1.15	0.47	0.47	0.91	0.14	0.16
Quadratic Trend (QT)	0.00	2.26	2.78	0.91	1.25	0.21	0.44	0.60
Harvey-Clark (HC)	0.29	0.59	0.78	0.57	1.01	0.71	0.30	0.52

Notes: The data sample for the output gap estimation starts in 1990Q1.

MAR is the mean absolute revision.

RMSR is the root mean square revision.

AR is the first-order serial correlation of the revision series.

N/S is a *proxy* for the noise-to-signal ratio (obtained by the ratio of the RMSR to the standard deviation of the final output gap).

CORR is the correlation between real-time and final output gap.

OPSIGN is the frequency with which real-time and final output gap estimates have opposite signs.

FRLA is the frequency with which the absolute value of the revision is larger than the absolute value of the final gap.

In order to measure the magnitude of the revisions, we use the same indicators used for GDP growth: the mean absolute revision (MAR) and the root mean square revision (RMSR). According to those indicators, the output gap measured by all the analyzed methods was revised substantially. The QT-based gap, which has a zero mean revision, had the largest MAR (2.16 p.p.). In absolute terms, this means that the QT-based output gaps were revised 2.26 p.p. on average, above or below the real-time initial release. The lowest MAR corresponds to the HC method (0.59 p.p.). The MAR of HP- and LT-based gaps was 0.84 p.p. and 0.89 p.p., respectively. Furthermore, the RMSR, which penalizes more strongly the larger revisions, is high for all the methods.

The first-order correlation (AR) shows the degree of persistence of the revisions. A high persistence reveals that the “errors” of the real-time gap estimates

(considering that the final estimates are the “best” available estimates) persist over long periods. In this case, real-time output gap estimates may lead policy makers and other economic agents to mistaken perceptions about the business cycle state.²⁷ Among the analyzed methods, the series of revision of the QT method shows the highest persistence (0.91) and that of the LT method, the lowest (0.47).

The noise-to-signal ratio (N/S) is an important measure because it considers the differences in the variability of the gaps estimated by the different methods. The QT- and HC-based gaps show N/S values greater than 1, whereas for the HP it is 0.92. In the case of linear trend, the N/S ratio is relatively low (0.47), at the same time the correlation between final and real-time gaps is the highest (0.91). This means that the real-time series of the LT explains 81 percent of the variance of the final series. The lowest correlation coefficient was that of the QT method, 0.21 – the real-time series explains only 5 percent of the variance of the final series.

However, we should note that the correlations can underestimate the importance of the revisions because they do not take into account the level of the series. Thus, we also use a further indicator, OPSIGN, which is the relative frequency in which the sign of the real-time output gap is different from that of the final estimate. This indicator is particularly important to assess the capability of the output gap to point whether monetary policy is tight or loose. The absence of any revision or change in the sign would generate a zero value for the OPSIGN. If we replaced the real-time series by a Gaussian white noise, we would obtain a value close to 0.50. Table 12 shows a high OPSIGN for three out of the four methods: QT (0.44), HP (0.30) and HC (0.30). For instance, this means that 44 percent of the real-time gaps estimated by the QT method show the “wrong” sign. The LT method presents the lowest OPSIGN (0.14).

²⁷ High persistence does not mean that revisions are predictable, but implies that future information will affect the output gap estimates of consecutive periods in a similar way. For instance, let say the real-time gap for a specific period is a substantial positive value. However, let’s assume that the final gap for the same period ends up showing that the gap was negative. In this case, in real time, based only on the gap measure, economic agents would have a mistaken perception about the business cycle state. If the AR parameter is high (i.e., if the series shows high persistence), this implies that the mistaken perception about the business cycle tends to persist over several quarters.

Finally, Table 12 records the FRLA indicator, which is the relative frequency in which the gap revision is greater than the final gap, both in absolute values. FRLA is superior to 0.50 for the QT and HC methods, indicating that, in more than 50 percent of the cases, the magnitude of the revisions is higher than the magnitude of the final gap. The HP gap also has large FRLA, 0.46, whereas the lowest is that of LT, 0.16.

Although, based on the revisions, we are not able to compare the methods according to their capacity of estimating the gaps correctly — we do not know the true errors associated with the final estimates of each method — some considerations about the revisions are warranted. Notwithstanding the quadratic trend-based output gap does not have revision bias (the total average revision is zero), in general, it has the most unfavorable revision indicators — the highest MAR, RMSR, N/S, FRLA, and AR, the lowest correlation between the real-time and final series, and the highest relative frequency of wrong signs. On the other hand, although the linear trend-based gap has the highest bias and large MAR and RMSR indicators, it shows the most favorable results for other revision indicators — the lowest N/S, FRLA, AR, and relative frequency of wrong signs (OPSIGN), and the highest correlation between the real-time and final series.

In order to compare our indicators to those of other countries, Table 13 records also the revision indicators of the output gap estimated in studies for the United States, Canada and Norway. In general, the revision indicators in these countries are even more unfavorable. In most of the cases, the revisions show higher RMSR, AR, N/S, OPSIGN and FRLA, and lower correlation between the final and real-time gaps. For some indicators, however, the QT-based output gaps for the U.S. and Canada had results more favorable than those for Brazil.

Table 13
Revision Indicators - Output Gap (%)
Results of some studies (*)

	Mean Revision	MAR	RMSR	AR	N/S	CORR	OPSIGN	FRLA
Hodrick-Prescott (HP)								
Brazil	0.04	0.84	1.08	0.63	0.92	0.64	0.30	0.46
United States (+)	0.30	**	1.83	0.93	1.11	0.49	0.41	**
Canada (++)	0.33	**	1,85(^)	0.93	1,23(^)	0.38	0.45	**
Norway (+++)	0.02	**	2,13(^)	0.73	1.53	-0.01	0.53	0.75
Linear Trend (LT)								
Brazil	0.40	0.89	1.15	0.47	0.47	0.91	0.14	0.16
United States (+)	4.78	**	5.12	0.91	1.32	0.89	0.49	**
Canada (++)	12.51	**	13,65(^)	0.99	1,48(^)	0.81	0.51	**
Norway (+++)	1.79	**	2,58(^)	0.82	0.79	0.83	0.25	0.33
Quadratic Trend (QT)								
Brazil	0.00	2.26	2.78	0.91	1.25	0.21	0.44	0.60
United States (+)	1.25	**	2.91	0.96	1.07	0.58	0.35	**
Canada (++)	3.33	**	5,12(^)	0.99	1,30(^)	0.60	0.40	**
Norway (+++)	-4.39	**	5,66(^)	0.94	1.53	0.33	0.44	0.64
Harvey-Clark (HC)								
Brazil	0.29	0.59	0.78	0.57	1.01	0.71	0.30	0.52
United States (+)	1.17	**	1.82	0.92	0.84	0.77	0.34	**
Canada (++)	1.62	**	2,82(^)	0.92	2,03(^)	-0.19	0.63	**
Norway (+++)	0.58	**	3,15(^)	0.83	1.00	0.22	0.53	0.53

Notes: The data sample for the output gap estimation starts in 1990Q1 for Brazil, in 1947Q1 for the United States, and in 1947Q1 for Canada. This information is not available for Norway.

MAR is the mean absolute revision.

RMSR is the root mean square revision.

AR is the first-order serial correlation of the revision series.

N/S is a proxy for the noise-to-signal ratio (obtained by the ratio of the RMSR to the standard deviation of the final output gap).

CORR is the correlation between real-time and final output gap.

OPSIGN is the frequency in which real-time and final output gap estimates have opposite signs.

FRLA is the frequency with which the absolute value of the revision is larger than the absolute value of the final gap.

(*) Analysis periods: Brazil: 1996Q1-2008Q2; United States: 1966Q1-1997Q4; Canada: 1972Q1-2003Q4;

Norway: 1993Q1-2002Q1.

(**) Not available.

(^) Computed in this work by using the means and standard deviations presented in the original works.

(+) Orphanides and van Norden (2002).

(++) Cayen and van Norden (2005).

(+++) Bernhardsen et al. (2004).

4.4. Decomposition of the output gap revisions

As stressed in Section 4.2, the total output gap revisions can be decomposed into two components — part associated with the GDP series revision, and part related to the sample size (revisions associated with the increase in the sample are mainly related

to the low precision of the end-of-sample estimates of the output trend). Those components are identified in Table 14.²⁸

Table 14
Decomposition of Output Gap Revision (%)
1996Q1-2008Q2

Method	Mean	Standard Deviation	Minimum Value	Maximum Value	MAR	RMSR	N/S	AR
Hodrick-Prescott (HP)								
Total revision	0.04	1.09	-1.77	2.75	0.84	1.08	0.92	0.63
Data revision effect	0.15	0.79	-2.49	1.73	0.60	0.80	0.68	0.39
Sample size effect	-0.11	1.21	-1.84	2.42	1.02	1.20	1.02	0.97
Linear Trend (LT)								
Total revision	0.40	1.08	-1.51	2.97	0.89	1.15	0.47	0.47
Data revision effect	0.38	1.47	-3.08	3.28	1.19	1.50	0.61	0.72
Sample size effect	0.02	1.67	-1.93	2.93	1.45	1.66	0.68	0.98
Quadratic Trend (QT)								
Total revision	0.00	2.80	-3.88	5.52	2.26	2.78	1.25	0.91
Data revision effect	0.52	0.78	-1.66	2.12	0.69	0.93	0.42	0.36
Sample size effect	-0.52	3.15	-4.24	5.17	2.79	3.17	1.42	0.96
Harvey-Clark (HC)								
Total revision	0.29	0.74	-1.38	2.20	0.59	0.78	1.01	0.57
Data revision effect	0.32	0.67	-1.57	1.97	0.55	0.73	0.94	0.42
Sample size effect	-0.03	0.33	-0.55	0.80	0.28	0.33	0.42	0.77

Notes: The data sample for the output gap estimation starts in 1990Q1.

MAR is the mean absolute revision.

RMSR is the root mean square revision.

N/S is a proxy for the noise-to-signal ratio (obtained by the ratio of the RMSR to the standard deviation of the final output gap).

AR is the first-order serial correlation of the revision series.

In the HP method, the positive bias generated by the data revision (0.15 p.p.) is largely offset by the negative bias resulted from the sample increase (-0.11 p.p.). The MAR, RMSR and N/S indicators show that both data revision and the sample increase are relevant to explain the magnitude of total revisions. For instance, the MAR coming from the data revision is 0.60 p.p., and the one stemming from the sample increase is 1.02 p.p. However, we cannot assert in an unambiguous way that the sample increase accounts for the largest part of the total MAR since, without that effect, the MAR would

²⁸ In Table 14, the “total revision” refers to the series obtained by the difference between the final and real-time series; the “effect of the data revision” refers to the series obtained by the difference between the quasi-real and real-time series; and the “effect of the sample size” refers to the series obtained by the difference between the final and quasi-real series.

be 0.60 p.p., close to the total MAR, of 0.84 p.p. In other words, at the margin, the effect of the sample size raised the MAR by 0.24 p.p. Similar reasoning applies to the case of the RMSR and N/S indicators. Figure 11 depicts the quasi-real and real-time series of the HP-based output gap. The difference between them is the revision of the gaps due to the GDP data revision. Figure 12, in turn, presents the final and real-time output gap series.²⁹ The difference between them is the revision stemming from the sample increase. The effect of the sample increase, in turn, includes the border problem of the HP filter.³⁰

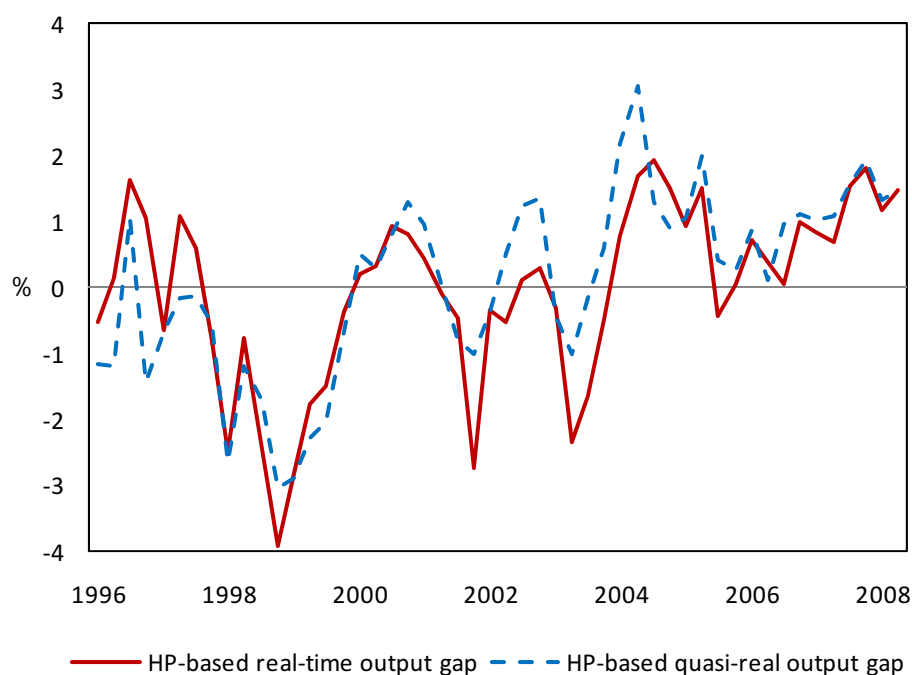


Figure 11 – HP-based output gap – Real-time and quasi-real series

In the case of the LT method, the total revision bias (0.40 p.p.) stems basically from the data revision (0.38 p.p.). However, the MAR, RMSR and N/S indicators show that the effect of the sample increase is also important to explain the magnitude of the total revision.

²⁹ See the appendix for graphs analogous to those of Figures 11 and 12 for the other three detrending methods.

³⁰ Close to the end of the sample, the HP filter eliminates cycles with frequency higher than it is supposed to eliminate. See Baxter and King (1999), and Mise, Kim and Newbold (2005).

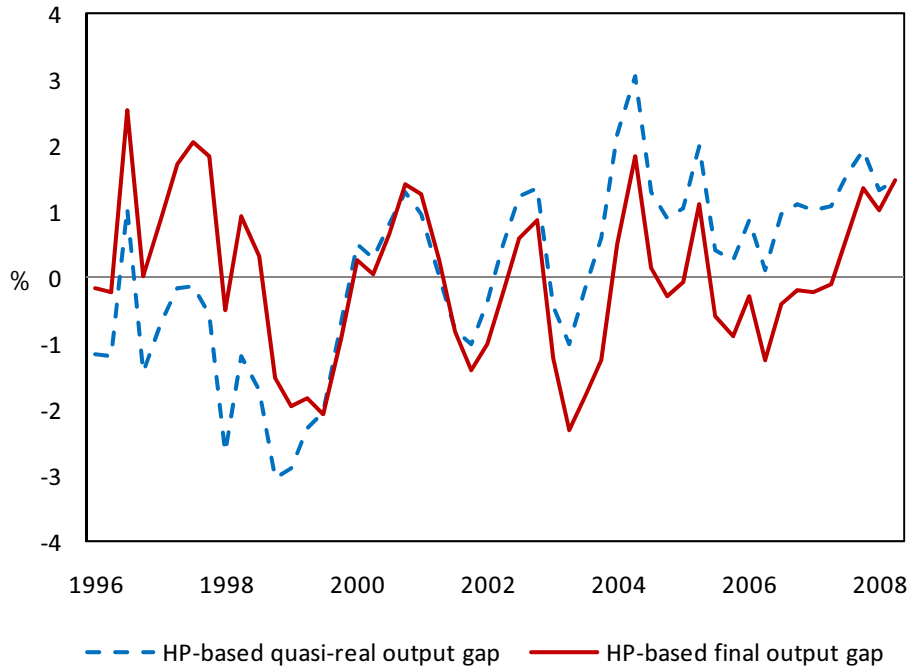


Figure 12– HP-based output gap – Quasi-real and final series

In the QT method, the total revision does not have bias. However, this results from a positive bias (0.52 p.p.) generated by the data revision that is fully offset by a negative bias arising from the sample increase (-0.52 p.p.). The MAR, RMSR, and N/S indicators show that the effect of the sample increase is highly superior to the effect of the data revision on the magnitude of total revision.

In the HC method, the total revision bias (0.29 p.p.) is basically due to the data revision (0.32 p.p.), offset only partially by the negative bias from the sample increase (-0.03 p.p.). Differently from the previous methods, the MAR, RMSR, and N/S indicators show that the effect of the data revision is greater than the effect of the sample increase on the magnitude of total revision.

Therefore, in general, in order to explain the magnitude of the total revision, the effect of both the sample increase and the data revision are relevant. However, in the QT method, the effect of the sample increase is clearly more important, whereas in the HC method the effect of the data revision is preponderant. Besides, in all methods, the largest part of the persistence of the total revision series comes from the sample increase.

On the other hand, in most of the cases, the largest part of the total revision bias stems from the data revision. Table 15 suggests that this is largely due to the methodological change in the GDP calculation introduced with the 2006Q4 vintage. With the previous methodology, in all methods, most of the bias up to 2006Q4 arose from the sample size. With the introduction of the new methodology, the bias coming from the data revision became predominant.

Table 15
Output gap bias and the 2006Q4 methodological change
1996Q1-2006Q4

Method	Mean	
	Previous methodology (*)	New methodology (**)
Hodrick-Prescott (HP)		
Total revision	0.28	0.22
Data revision effect	-0.01	0.13
Sample size effect	0.28	0.08
Linear Trend (LT)		
Total revision	1.59	1.25
Data revision effect	-0.14	0.37
Sample size effect	1.73	0.88
Quadratic Trend (QT)		
Total revision	0.61	0.48
Data revision effect	0.13	0.55
Sample size effect	0.49	-0.07
Harvey-Clark (HC)		
Total revision	0.05	0.32
Data revision effect	0.01	0.33
Sample size effect	0.05	-0.01

Notes: The data sample for the output gap estimation starts in 1990Q1.

Due to rounding off, the sum of the data revision and sample size means may be different from the total revision mean.

(*) The output gap series from this column were computed by using the 2006Q4 vintage referring to the previous methodology.

(**) The output gap series from this column were computed by using the 2006Q4 vintage referring to the new methodology.

In order to compare the decomposition of the revisions in Brazil with the results found in studies for other countries, we use Table 16, which shows some indicators of revision decomposition for Brazil, United States, Canada and Norway. Among those, the most adequate to assess the decomposition of the total revision

magnitude is the noise-to-signal ratio. When this information is not available, we can observe the mean — when the magnitude of the mean of one of the effects is large and much superior to the magnitude of the mean of the other effect, this effect is likely to be preponderant in absolute terms.³¹

Table 16
Decomposition of the output gap revisions (%)
Results of some studies (*)

	Mean				N/S				AR			
	Brazil	U.S	Canada	Norway	Brazil	U.S	Canada	Norway	Brazil	U.S	Canada	Norway
Hodrick-Prescott (HP)												
Total revision	0.04	0.30	0.33	0.02	0.92	1.11	1,06(^)	1.53	0.63	0.93	0.93	0.73
Data revision effect	0.15	0.16	0.23	0.25	0.68	0,40(^)	0,37(^)	0.68	0.39	0.66	0.60	0.04
Sample size effect	-0.11	0.14	0.11	-0.23	1.02	0,97(^)	0,94(^)	1.27	0.97	0.97	0.98	0.96
Linear Trend (LT)												
Total revision	0.40	4.78	12.51	1.79	0.47	1.32	2,13(^)	0.79	0.47	0.91	0.99	0.82
Data revision effect	0.38	0.80	1.41	2.48	0.61	0,37(^)	0,34(^)	0.89	0.72	0.79	0.91	0.87
Sample size effect	0.02	3.95	11.10	-0.69	0.68	1,12(^)	1,91(^)	0.28	0.98	0.96	0.99	0.95
Quadratic Trend (QT)												
Total revision	0.00	1.25	3.33	-4.39	1.25	1.07	1,11(^)	1.53	0.91	0.96	0.99	0.94
Data revision effect	0.52	0.23	2.03	0.99	0.42	0,39(^)	0,52(^)	0.41	0.36	0.76	0.87	0.53
Sample size effect	-0.52	1.00	1.30	-5.38	1.42	0,97(^)	0,81(^)	1.65	0.96	0.99	0.99	0.98
Harvey-Clark (HC)												
Total revision	0.29	1.17	1.62	0.58	1.01	0.84	1,77(^)	1.00	0.57	0.92	0.92	0.83
Data revision effect	0.32	0.27	0.66	0.08	0.94	0,31(^)	0,78(^)	0.18	0.42	0.84	0.72	-0.41
Sample size effect	-0.03	0.90	0.96	0.50	0.42	**	**	0.98	0.77	**	**	0.91

Notes: The data sample for the output gap estimation starts in 1990Q1 for Brazil, in 1947Q1 for the United States, and in 1947Q1 for Canada. This information is not available for Norway .

N/S is a proxy for the noise-to-signal ratio (obtained by the ratio of the RMSR to the standard deviation of the final output gap).

AR is the first-order serial correlation of the revision series.

(*) Analysis periods and sources: Brazil: 1996Q1-2008Q2; United States: 1966Q1-1997Q4 (Orphanides and van Norden, 2002); Canada: 1972Q1-2003Q4 (Cayen and van Norden, 2005); Norway: 1993Q1-2002Q1 (Bernhardsen et al., 2004).

(**) Not available.

(^) Computed in this work by using the means and standard deviations presented in the original works.

We can observe that, in most of the cases in Table 16, in line with the findings for Brazil, both the effect of the sample increase and the effect of the data revision play an important role to explain the magnitude of total revision, although we can note that

³¹ The noise-to-signal ratio is calculated as $N/S = RMSR/SD_{final}$, where $RMSR$ is the root mean square revision, and SD_{final} is the standard deviation of the final output gap series. However, $RMSR = \sqrt{M_{rev}^2 + SD_{rev}^2}$, where M_{rev} and SD_{rev} are the mean and the standard deviation of the revision series, respectively. Thus, the higher the magnitude of the revision series mean, the higher the RMSR and the N/S.

there is some predominance of the effect of the sample increase for the other countries. In fact, differently from the findings for Brazil, in most of the cases, the bias coming from the sample increase predominates over the bias arising from the data revision (except for the HP method). Besides, in most of the cases, the data revision series of the other countries have higher persistence than the corresponding Brazilian series.

5. Conclusion

We have constructed a real-time data set for Brazil, containing all vintages of the seasonally adjusted quarterly GDP, released by the IBGE from 1996Q1 through 2008Q2. Based on this data set, we assess the importance of the revisions of the real-time series of GDP growth and output gap. Since we neither associate specific applications with the revisions, nor make assumptions about the true structure of the economy or the true data generating process, the results are fairly general and capture part of the measurement error of those variables.

Our results suggest that the revisions of the quarter-over-quarter GDP growth rate are substantial. In absolute values, GDP growth is revised, on average, 0.67 p.p. above or below the initial released value. In 16 percent of the cases, the GDP growth revision implies a change in the sign. In 26 percent of the time, the magnitude of the GDP growth revision is greater than that of the data. Isolating the effects of the methodological change in the 2006Q4 vintage, our analysis suggests that this change is a relevant source of the revisions, although it explains only part of them.

Furthermore, corroborating Cayen and van Norden's (2004) findings for Canada, the GDP growth revisions become less important as the aggregation period increases. In fact, as we increase the aggregation period, several indicators become more favorable. For example, for the year-over-year GDP growth, the mean absolute revision falls to 0.23 p.p. per quarter (corresponding to 0.92 p.p. per year). In the case of the four-quarter GDP growth, the revision is even lower (0.64 p.p. per year).

To assess the output gap revisions, we used four detrending methods: HP filter, linear trend, quadratic trend, and the Harvey-Clark unobserved-components model. In

all cases, the magnitude of the output gap revisions was high. For instance, the HP-based output gap is revised, on average, 0.84 p.p. above or below its initial estimate. We found the highest revision biases for the LT- and HC-based output gaps, and the largest magnitude of revision for the LT- and QT-based gaps. In three out of the four methods (HP, QT and HC), the revisions implied a change in the output gap sign in 30 percent or more of the time, and the revision magnitude is higher than the gap magnitude in approximately 50 percent or more of the time. Some indicators show more favorable results for the LT method, in spite of having relevant bias and revision magnitude.

We found out that, in general, the effect of both the GDP data revision and the sample increase play an important role in explaining the magnitude of the total revisions of the output gap. However, in one of the methods (QT), the effect of the sample increase predominates over the effect of data revision, revealing that the revisions, in this case, are mainly associated with the low precision of the end-of-the-sample estimates of the output trend, whereas, in another method (HC), the effect of the data revision is more relevant. The fact that both effects are important to explain total revisions is in line with the findings in Orphanides and van Norden (2002) for the United States, Cayen and van Norden (2005) for Canada, and Bernhardsen et al. (2004, 2005) for Norway.

Although the revision indicators for Brazil's output gap are, in general, less unfavorable than those reported by studies for other countries, the Brazilian indicators suggest the presence of relevant limitations in real-time output gap estimates. This has important implications for monetary policy. In line with Orphanides and van Norden (2002), the results recommend that we should be very cautious when using those estimates. Policymakers should consider that, in real time, the output gap estimates tend not to be very reliable. Our results suggest further that, to assess monetary policy decisions made in the past or estimate a monetary policy rule that describes monetary authority's behavior (e.g. a Taylor rule), it may not be reasonable to use the last available data set. In these cases, one alternative is to use a real-time data set. Furthermore, our results question the procedure of comparing the performance of inflation forecasts made in real time with those of a model that employs the last

available data set. As the last available data set tends to be more precise, the comparison may be unfair.

Our results raise several questions to be investigated in more detail for the Brazilian case. Would monetary policy decisions made in the past be different if policymakers had access to all revised data? How different is a Taylor rule estimated with real-time data from one estimated using final data? What is the most adequate way of estimating a monetary policy rule (with real-time data or with final data)? To what extent does the use of final data, instead of real-time one, improve the performance of an inflation forecast model? And finally are output gap revisions predictable? Answers to these questions would improve our understanding of the limits that economic agents face in real time. Furthermore, they would allow a better comprehension of how to use the available information more efficiently.

The results of this work also point to the importance of using a larger information set — including other economic series — when analyzing the state of the business cycle. In principle, employing more information tends to reduce the risks associated with the use of series subject to revision. In fact, in general, central banks use a broad information set about economic activity and its prospects.³²

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³² For example, in the minutes of the meetings of the Monetary Policy Committee (Copom) of the Central Bank of Brazil, it is evident the use of a vast information set about economic activity.

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Appendix – Graphs for the GDP and output gaps estimated using LT, QT and HC.

A.1. Quarterly Brazil's GDP (in natural logarithm)

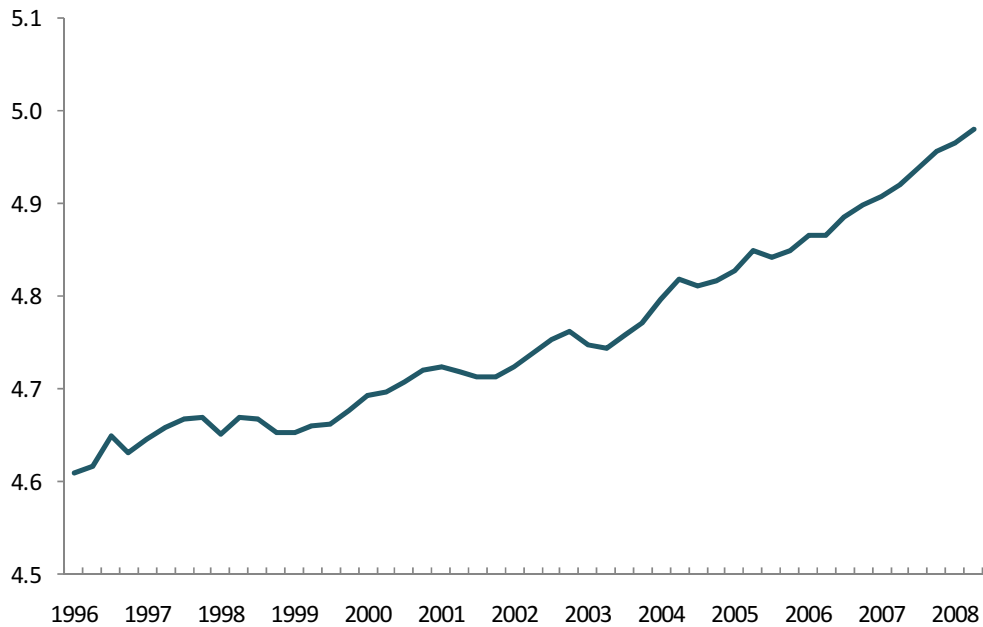


Figure A.1 – Final GDP (corresponding to the 2008Q2 vintage)

A.2. Linear Trend (LT)

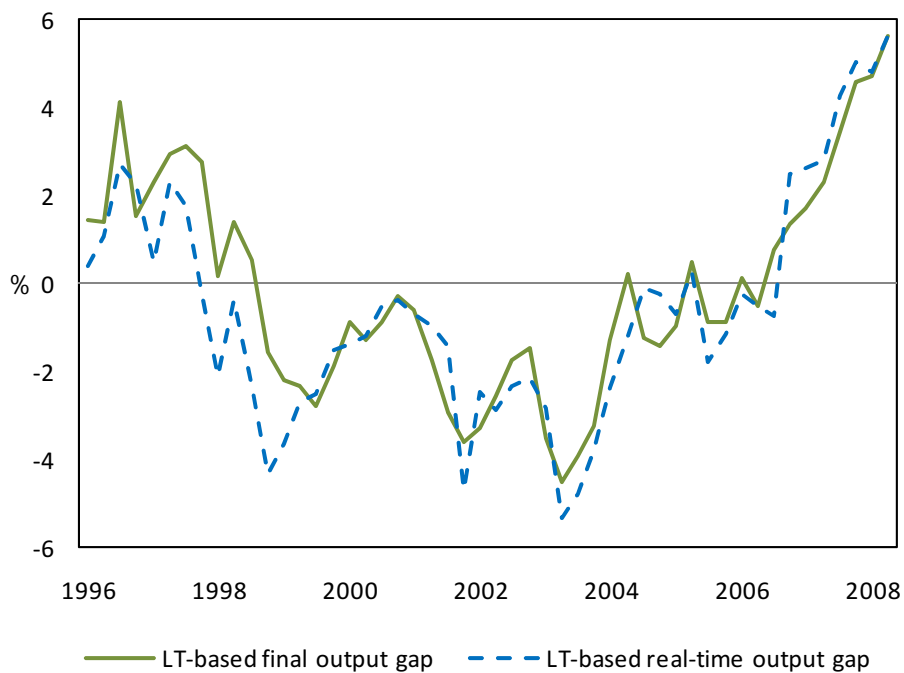


Figure A.2 – Final and real-time LT-based output gaps

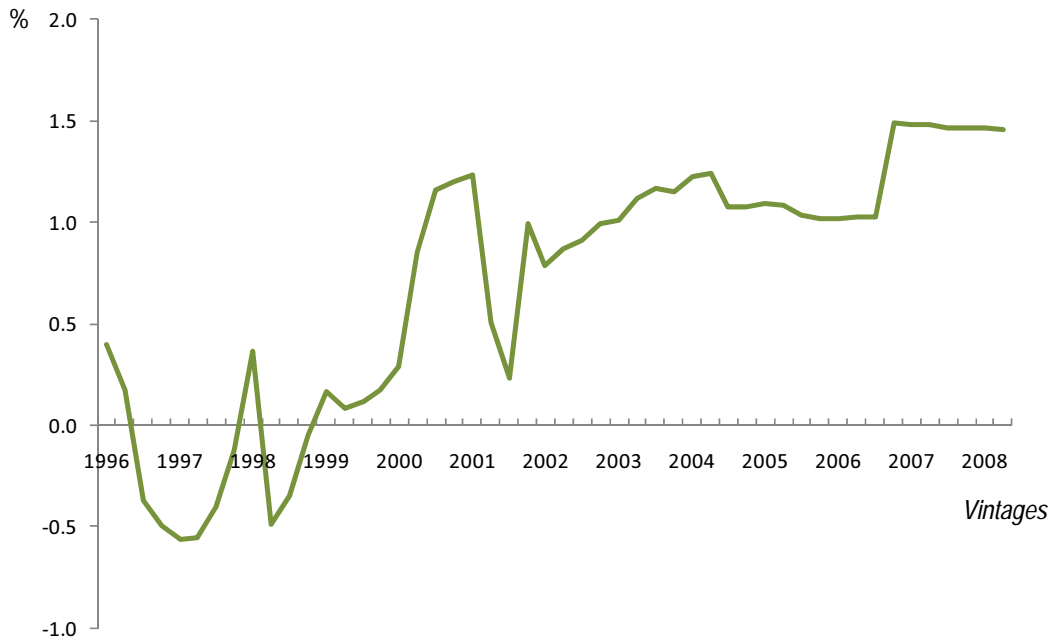


Figure A.3 – Output Gap (Linear Trend) of 1996Q1 over the revisions (% of GDP)

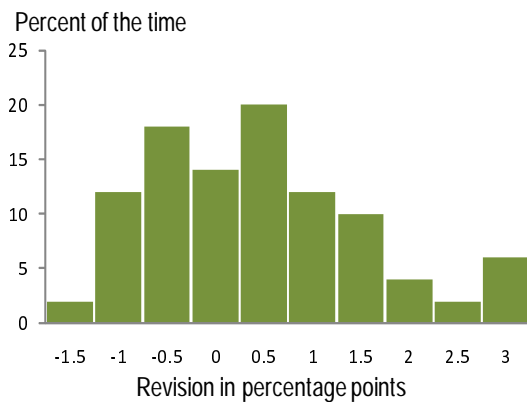


Figure A.4 – Relative frequency of the revisions of the LT-based output gap values

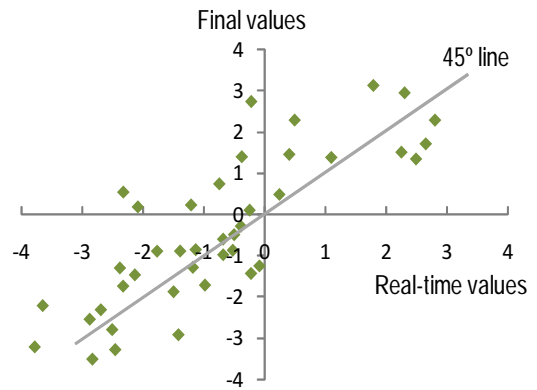


Figure A.5 – LT output gap values (real time *versus* final)



Figure A.6 – LT-based output gaps: Real-time and quasi-real series

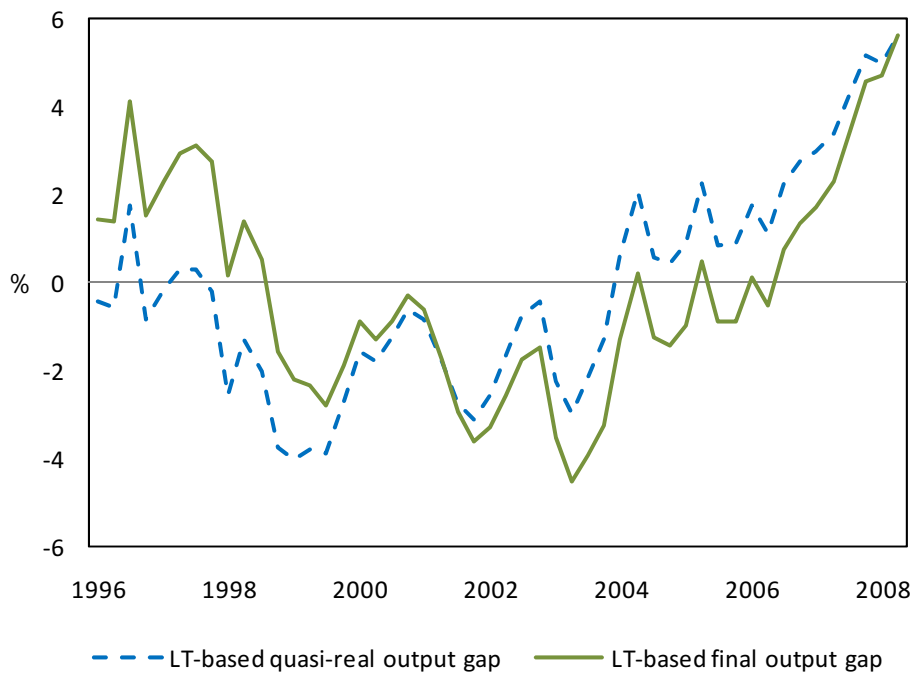


Figure A.7 – LT-based output gaps: Quasi-real and final series

A.3. Quadratic Trend (QT)

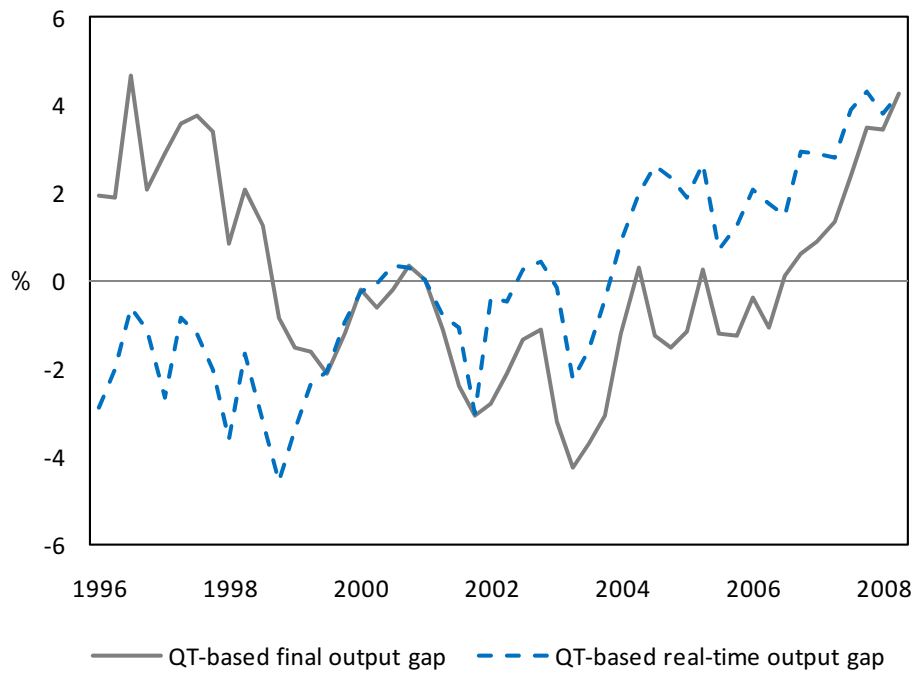


Figure A.8 – Final and real-time QT-based output gaps

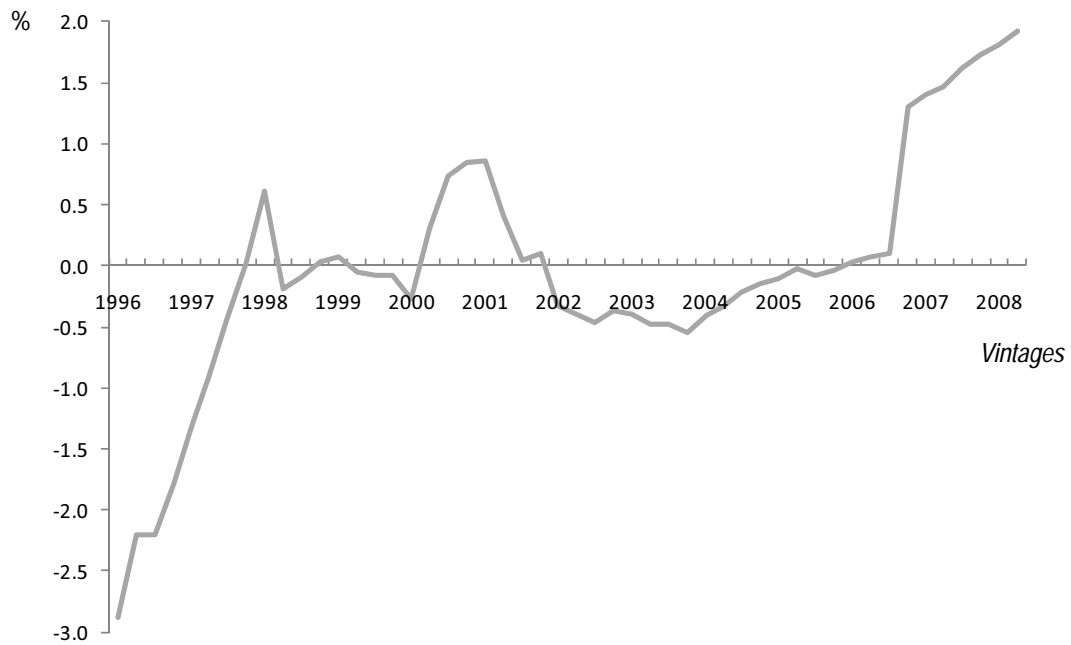


Figure A.9 – Output gap (Quadratic Trend) of 1996Q1 over the revisions (% of GDP)

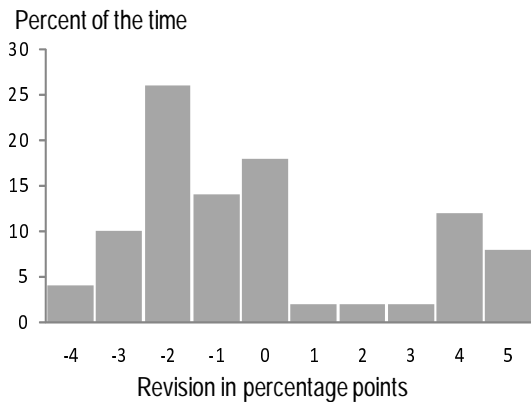


Figure A.10 – Relative frequency of the revisions of the QT-based output gap values

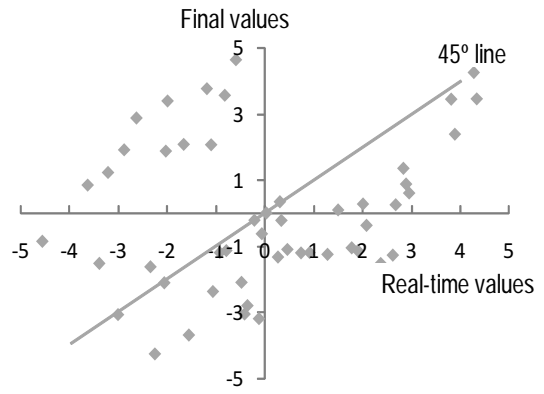


Figure A.11 – QT-based output gap values (real time *versus* final)

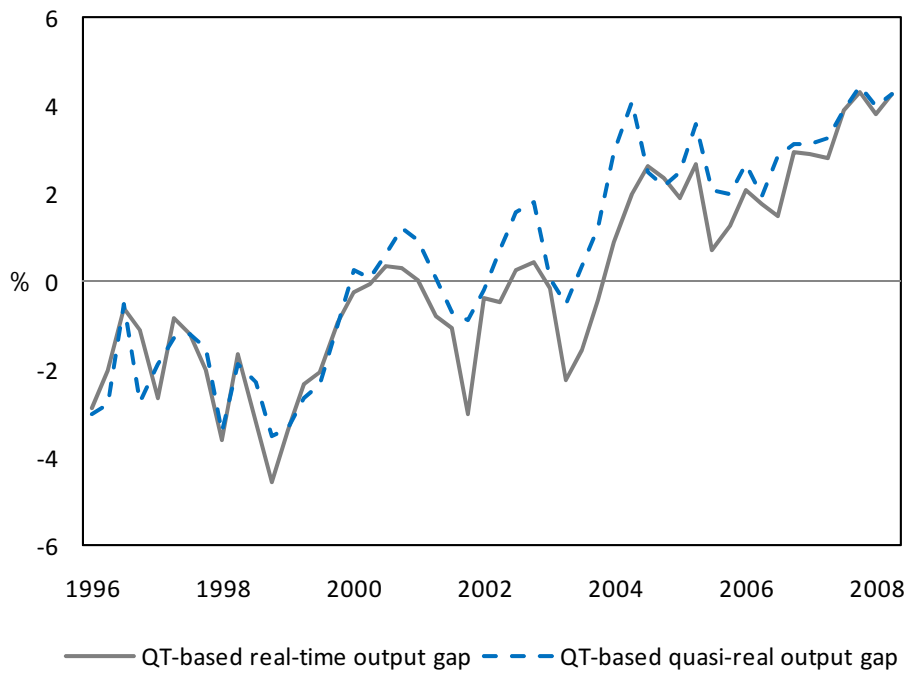


Figure A.12 –QT-based output gap – Real-time and quasi-real series

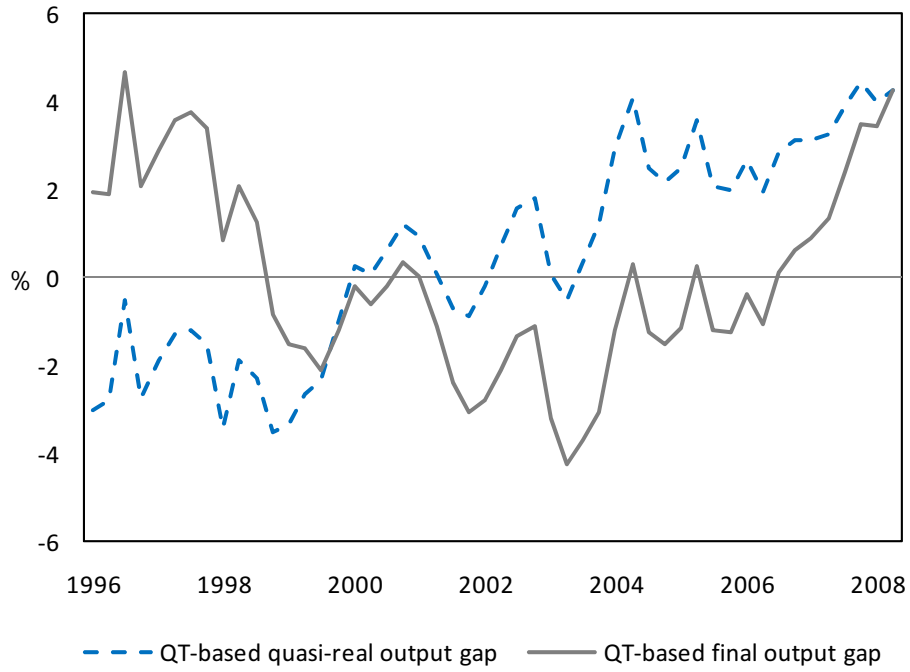


Figure A.13 – QT-based output gap – Quasi-real and final series

A.4. *Harvey-Clark (HC)*

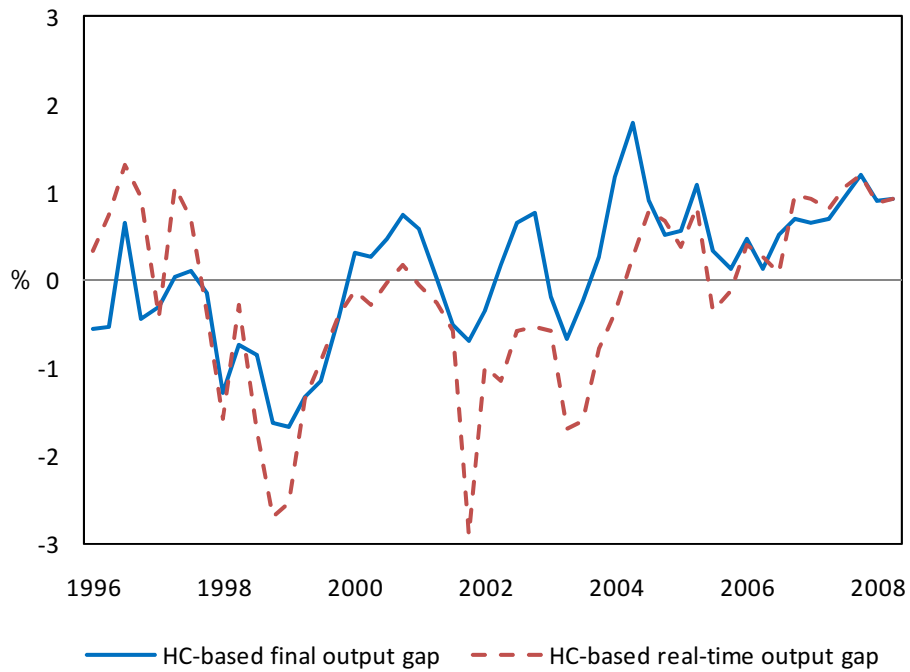


Figure A.14 – Final and real-time HC-based output gaps

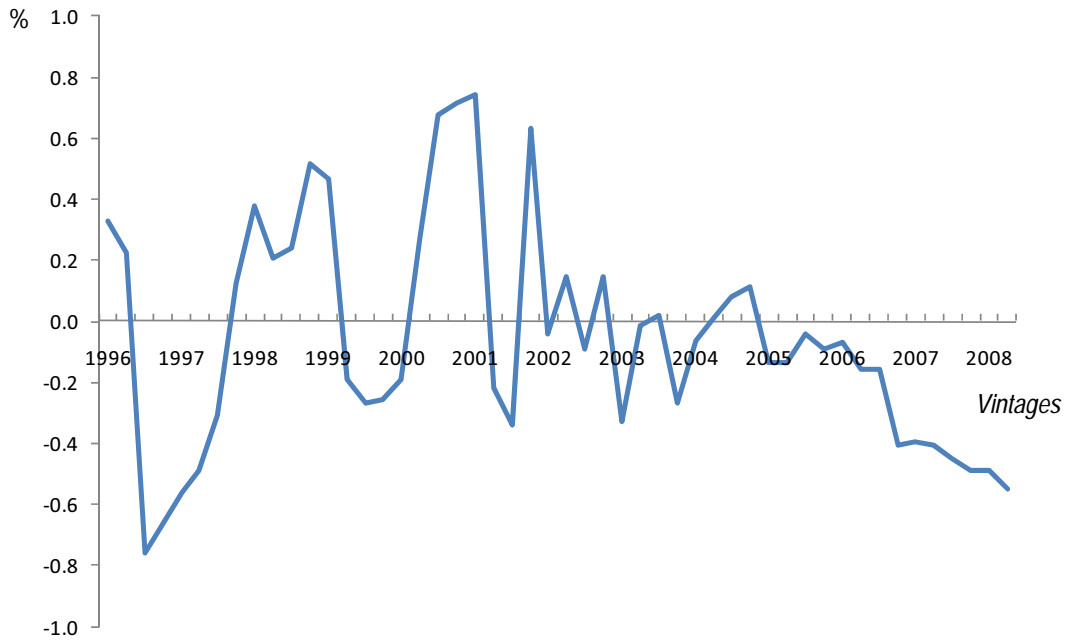


Figure A.15 – Output gap (Harvey-Clark) of 1996Q1 over the revisions (% of GDP)

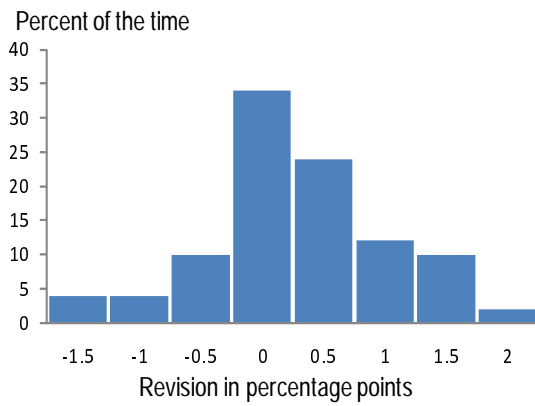


Figure A.16 – Relative frequency of the revision of the HC-based output gap values

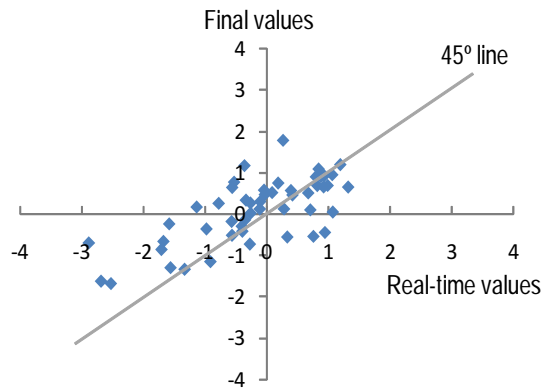


Figure A.17 – HC-based output gap values (real time versus final)

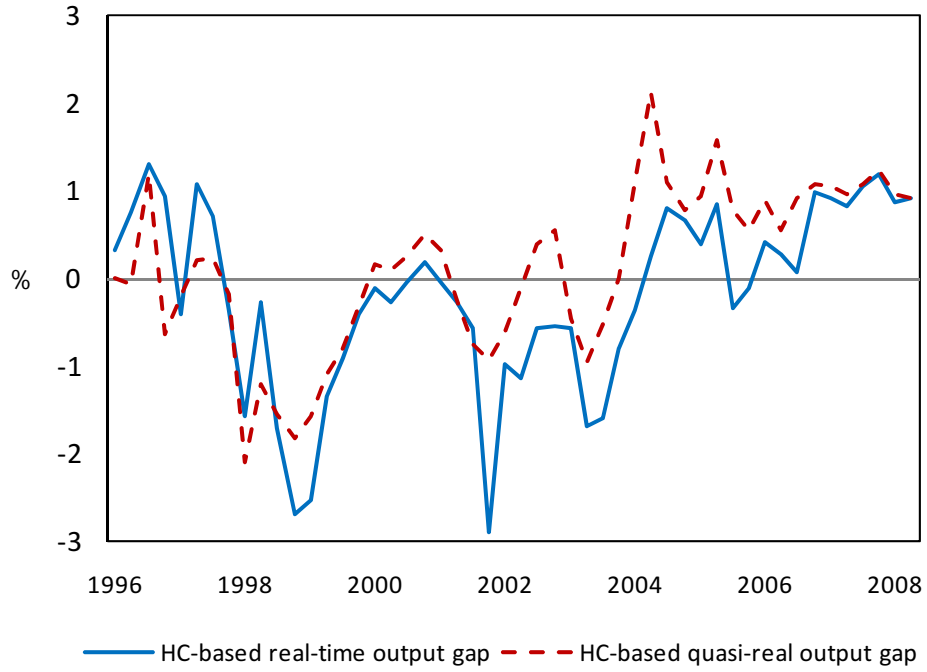


Figure A.18 – HC-based output gap values – Real-time and quasi-real series

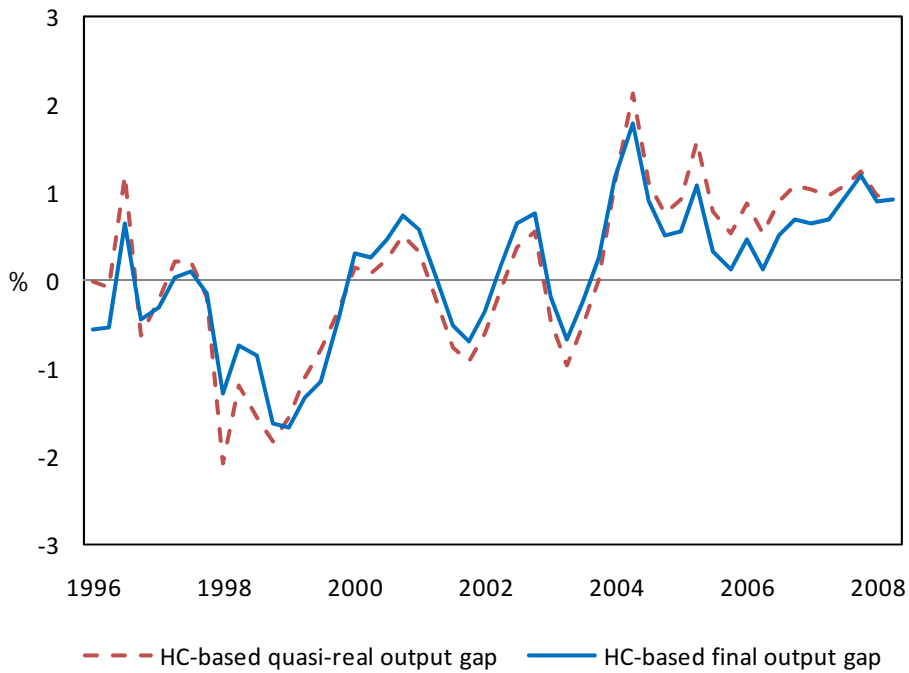


Figure A.19 – HC-based output gap values – Quasi-real and final series

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