ISSN 1518-3548

BANCO CENTRAL DO BRASIL

Working Paper Series 203

Output Gap and GDP in Brazil: a real-time data analysis

Rafael Tiecher Cusinato, André Minella and Sabino da Silva Pôrto Júnior

April, 2010

ISSN 1518-3548
CGC 00.038.166/0001-05

Working Paper Series	Brasília	n. 203	Apr.	2010	p. 1-65

Working Paper Series

Edited by Research Department (Depep) – E-mail: workingpaper@bcb.gov.br

Editor: Benjamin Miranda Tabak – E-mail: benjamin.tabak@bcb.gov.br
Editorial Assistant: Jane Sofia Moita – E-mail: jane.sofia@bcb.gov.br
Head of Research Department: Adriana Soares Sales – E-mail: adriana.sales@bcb.gov.br

The Banco Central do Brasil Working Papers are all evaluated in double blind referee process.

Authorized by Carlos Hamilton Vasconcelos Araújo, Deputy Governor for Economic Policy.

General Control of Publications

Banco Central do Brasil

Secre/Surel/Cogiv

SBS – Quadra 3 – Bloco B – Edifício-Sede – 1º andar

Caixa Postal 8.670

70074-900 Brasília – DF – Brazil

Phones: +55 (61) 3414-3710 and 3414-3565

Fax: +55 (61) 3414-3626

E-mail: editor@bcb.gov.br

Consumer Complaints and Public Enquiries Center

Banco Central do Brasil

Secre/Surel/Diate

SBS – Quadra 3 – Bloco B – Edifício-Sede – 2º subsolo

70074-900 Brasília – DF – Brazil

Fax: +55 (61) 3414-2553

Internet: http//www.bcb.gov.br/?english

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

Rafael Tiecher Cusinato**
André Minella***
Sabino da Silva Pôrto Júnior****

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.

---

* We are thankful to Cláudio D. Shikida, Roberto Camps de Moraes, Ronald O. Hillbrecht and participants in the XXXVII Anpec National Meeting of Economics for their comments and suggestions.
** 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. Croshoure 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 growth[2] 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)

	Real Time	Final	Data revision
Period	(A)	(B)	(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 $\left(GDP_{n,t}/GDP_{n-1,t}\right)$, 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.

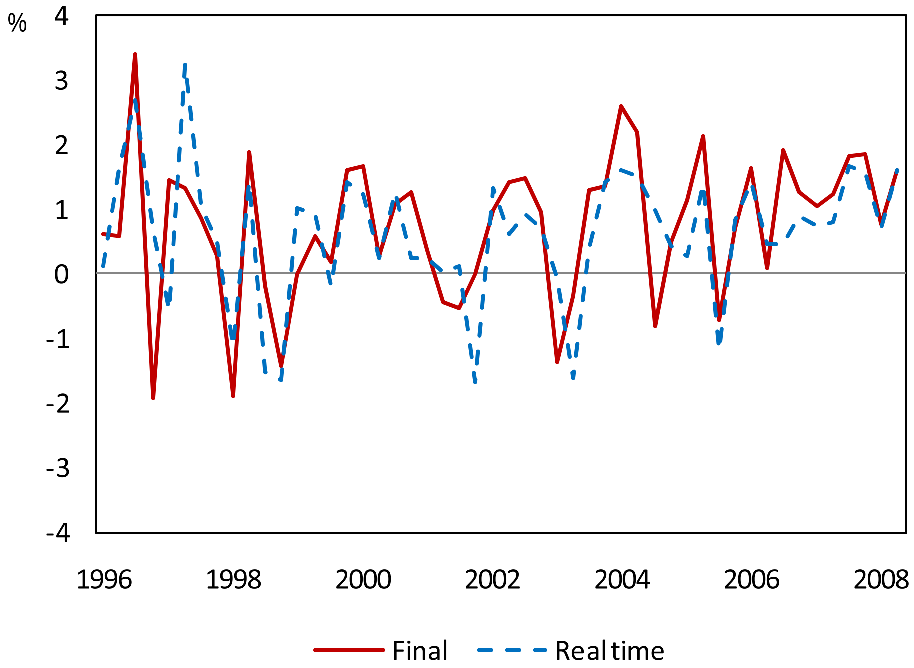

Figure 1 – Final and real-time GDP growth (%)
(quarter-over-quarter)

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.

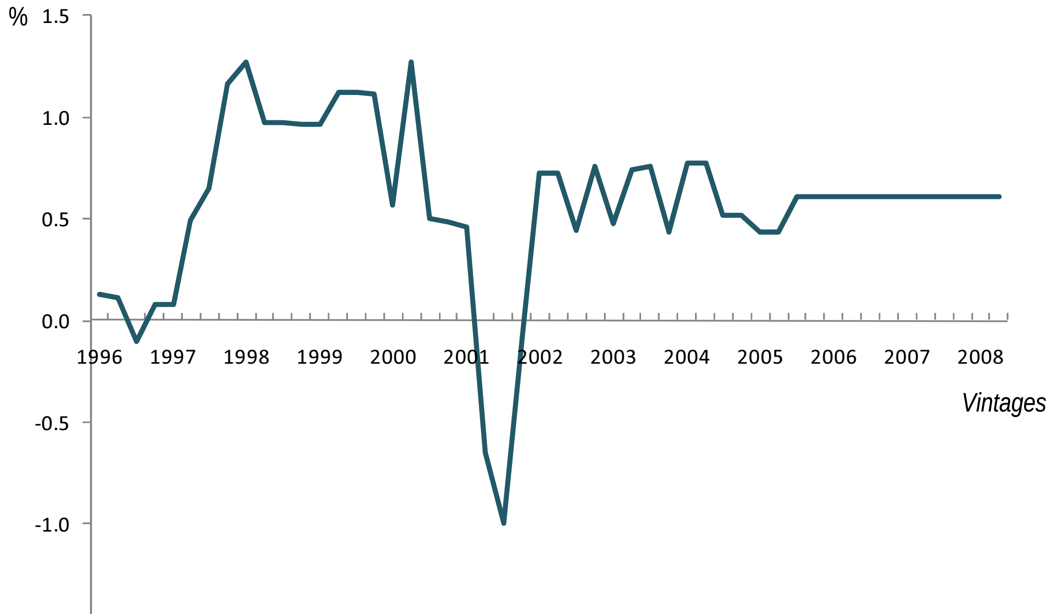

Figure 2 – GDP growth of 1996Q1 over the revisions (%)
(quarter-over-quarter)

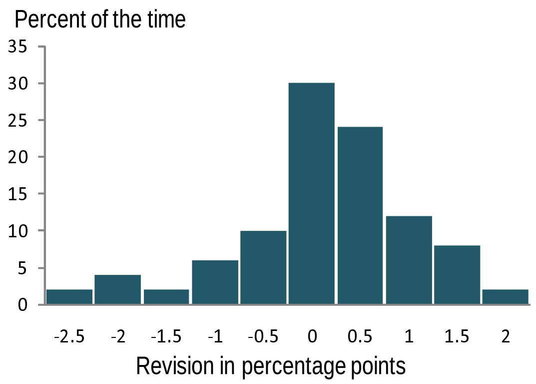

Figure 3 – Relative frequency of the revision of the GDP values

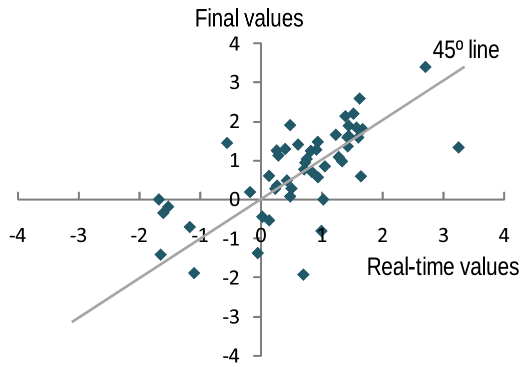

Figure 4 – GDP growth values (real-time *versus* final)

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 absolue 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 absolue 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]

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

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 that 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 absolue 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 betw een real-time and final GDP grow th.
(*) Period of analysis: Brazil: 1996Q1-2008Q2; Canada: 1972Q1-2003Q4.
(^) Computed in this w ork by using the means and standard deviations presented in the original w ork.

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.

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

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 $\lambda \to \infty$, 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 $\lambda \to 0$, 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, λ=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:

$$y_t = \alpha + \beta t + e_t \ , \quad t = 1, \dots, T. \tag{5}$$

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:

$$y_t = \alpha + \beta_1 t + \beta_2 t^2 + e_t \ , \quad t = 1, \dots, T. \tag{6}$$

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

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

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

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

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

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:

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

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

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 cautions 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.

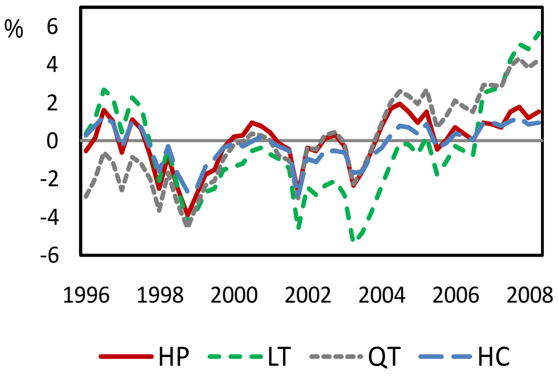

Figure 5 (a) – Real-time output gap

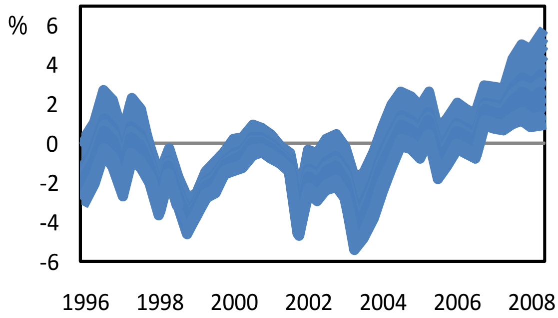

Figure 5 (b) – Real-time output gap – Thick Modeling

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.

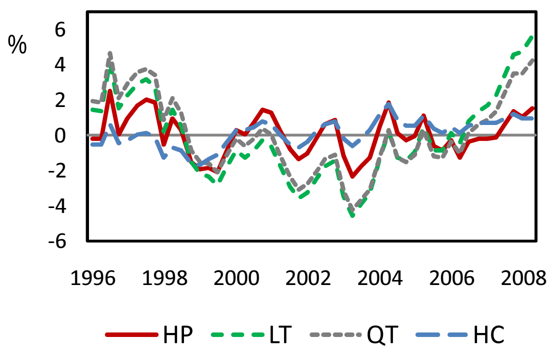

Figure 6 (a) – Final output gap

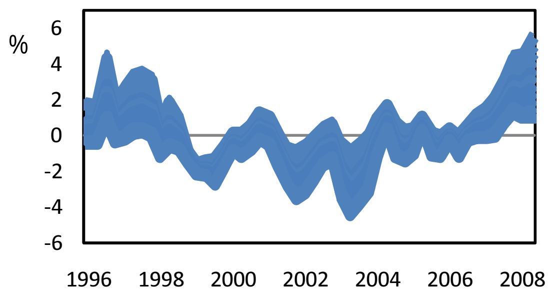

Figure 6 (b) – Final output gap – Thick Modeling

[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]

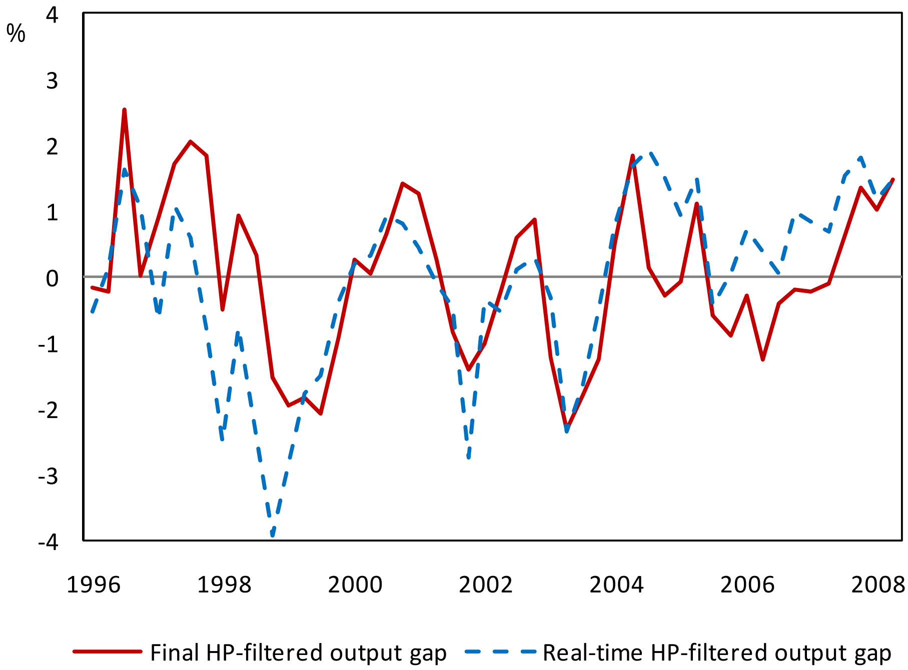

Figure 7 – Final and real-time HP-based output gaps

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]

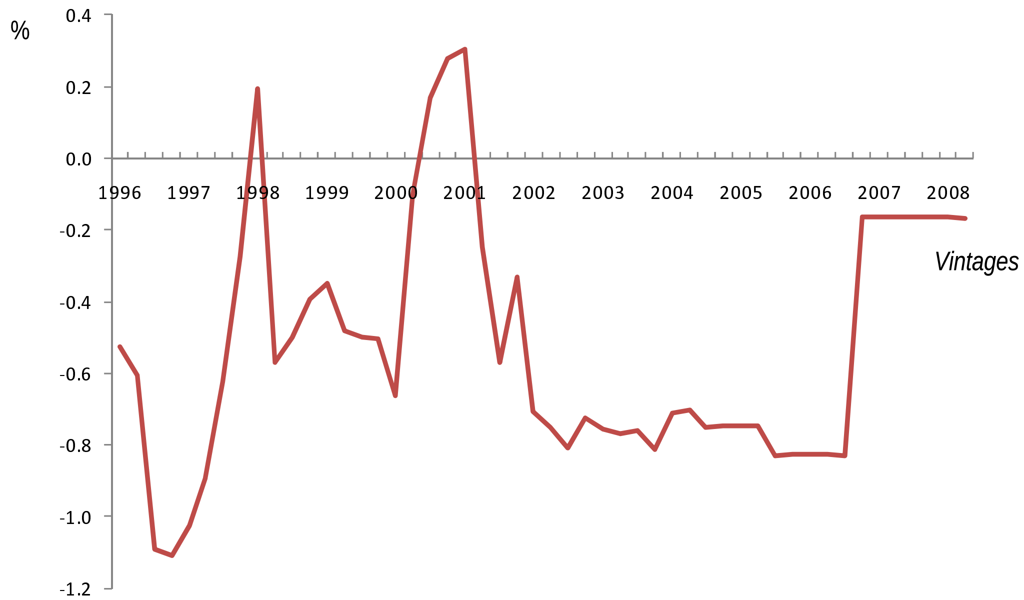

Figure 8 – Output gap (HP filter) of 1996Q1 over the revisions (% of GDP)

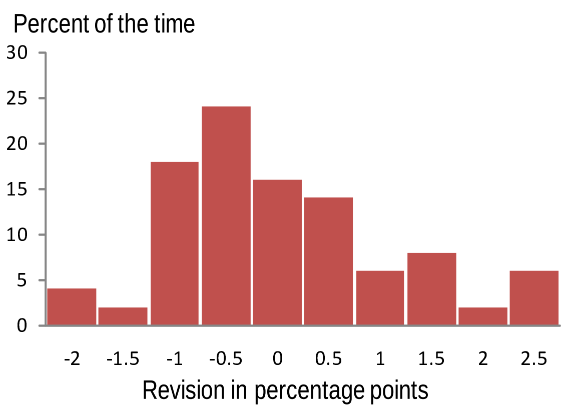

Figure 9 – Relative frequency of the revision of the values of the HP-based output gap

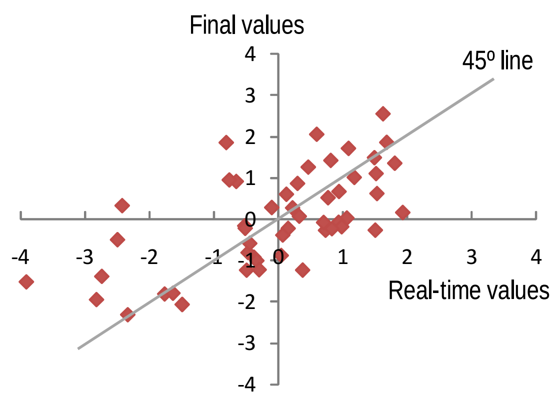

Figure 10 – HP-based output gap values (real-time *versus* final)

[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 λ=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 betw een real-time and final output gap.
OPSIGN is the frequency w hich real-time and final output gap estimates have opposite signs.
FRLA is the frequency w ith w hich the absolue 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 absolue 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]

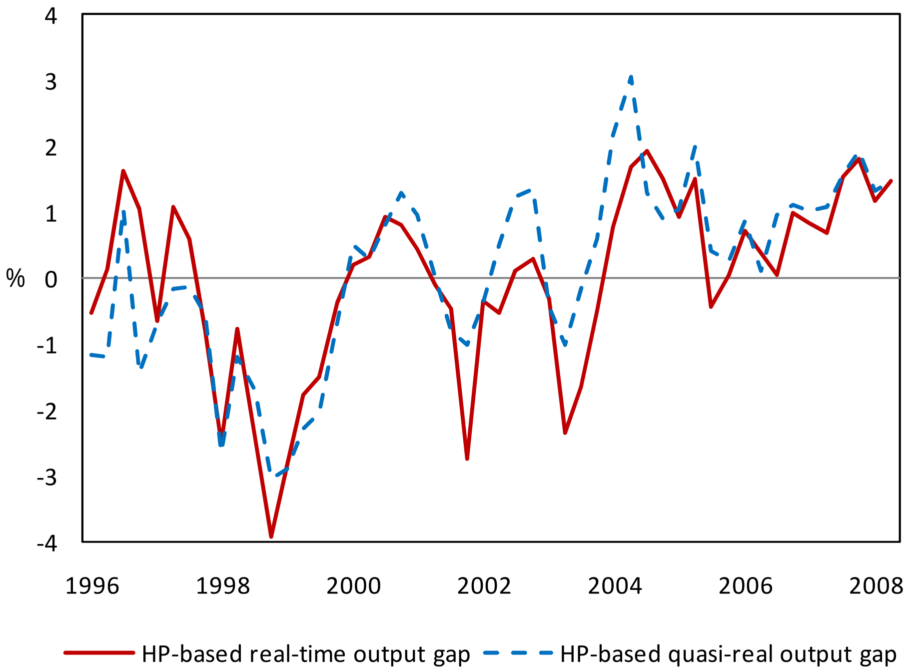

Figure 11 – HP-based output gap – Real-time and quasi-real series

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).

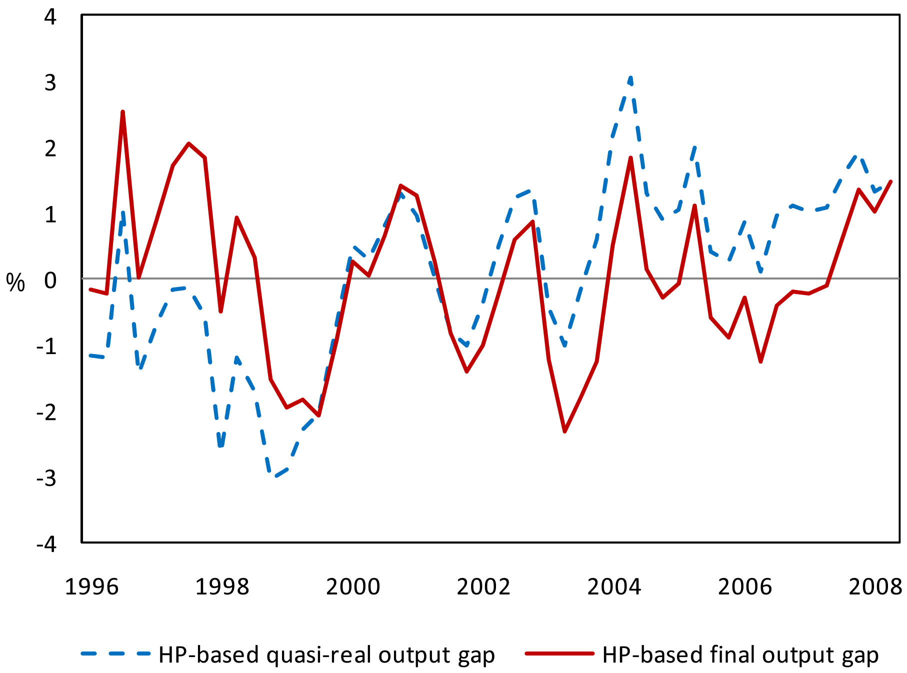

Figure 12– HP-based output gap – Quasi-real and final series

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 Stantes, 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]

References

AHMAD, Nadim; BOURNOT, Sophie; and KOECHLIN, Francette (2007), "Revisions to quarterly GDP estimates: a comparative analysis for seven large OECD Countries", Mimeo, OECD.

ARAÚJO, Carlos H. V.; and GUILLÉN, Osmani T. de C. (2008), "Previsão de inflação com incerteza do hiato do produto no Brasil", Mimeo, XXXVI Anpec National Meeting of Economics.

BAXTER, Marianne; and KING, Robert G. (1999), "Measuring business cycles: approximate band-pass filters for economic time series", *Review of Economics and Statistics*, v.81, no.4, 575-593.

[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.

BERNHARDSEN, Tom; EITRHEIM, Øyvind; JORE, Sofie Anne; and RØISLAND, Øistein (2004), "Real-time data for Norway: challenges for monetary policy", Discussion Paper Series 1: Studies of the Economic Research Centre, no.26, Deutsche Bundesbank.

BERNHARDSEN, Tom; EITRHEIM, Øyvind; JORE, Sofie Anne; and RØISLAND, Øistein (2005), "Real-time data for Norway: challenges for monetary policy", *North American Journal of Economics and Finance,* v.16, 333-349.

CAYEN, Jean-Philippe; and van NORDEN, Simon (2004), "The reliability of Canadian output-gap estimates", Discussion Paper Series 1: Studies of the Economic Research Centre, no.29, Deutsche Bundesbank.

CAYEN, Jean-Philippe; and van NORDEN, Simon (2005), "The reliability of Canadian output-gap estimates", *North American Journal of Economics and Finance,* v.16, 373-393.

CLARK, Peter K. (1987), "The cyclical component of U. S. economic activity", *The Quartely Journal of Economics,* v.102, no.4, 797-814.

CROSHOURE, Dean (2008), "Frontiers of real-time data analysis", Working Paper no.08-4, Research Department, Federal Reserve Bank of Philadelphia.

CROSHOURE, Dean; and STARK, Tom (2000), "A funny thing happened on the way to the data bank: a real-time data set for macroeconomists", *Business Review,* September/October, Federal Reserve Bank of Philadelphia.

CROSHOURE, Dean; and STARK, Tom (2001), "A real-time data set for macroeconomists", *Journal of Econometrics,* v.105, 111-130.

DIEBOLD, Francis X.; and RUDEBUSCH, Glenn D. (1991), "A real-time analysis", *Journal of the American Statistical Association*, v.86, no.415, 603-610.

GRANGER, Clive W.J; and JEON, Yongil (2004), "Thick Modeling", *Economic Modelling,* v.21, 323-343.

HARVEY, Andrew C. (1985), "Trends and cycles in macroeconomic time series", *Journal of Business and Economic Statistics*, v.3, 216-227.

HODRICK, Robert J.; and PRESCOTT, Edward C. (1997), "U.S business cycles: an empirical investigation", *Journal of Money, Credit and Banking*, v.29, no.1, 1-16.

IBGE (2008), "Contas nacionais trimestrais", *Série Relatórios Metodológicos*, no.28.

KIM, Chang-Jin; and NELSON, Charles R. (1999), *State-Space Models with Regime Switching: Classical and Gibbs-Sampling Approaches with Applications*, Cambridge: Massachusetts Institute of Technology.

MISE, Emi; KIM, Tae-Hwan; and NEWBOLD, Paul (2005), "On suboptimality of the Hodrick-Prescott filter at time series endpoints", *Journal of Macroeconomics*, v.27, 53-67.

ORPHANIDES, Athanasios; and van NORDEN, Simon (2002), "The unreability of output-gap estimates in real time", *The Review of Economics and Statistics*, v.84, no.4, 569-583.

PALIS, Rebeca de la Rocque; RAMOS, Roberto Luis Olinto; and ROBITAILLE, Patrice (2004), "News or Noise? An Analysis of Brazilian GDP Announcements", International Finance Discussion Papers, no. 776, Federal Reserve Board.

STARK, Tom (2002), "A summary of the conference on real-time data analysis", *Business Review,* Q1, 5-11, Federal Reserve Bank of Philadelphia.

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

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

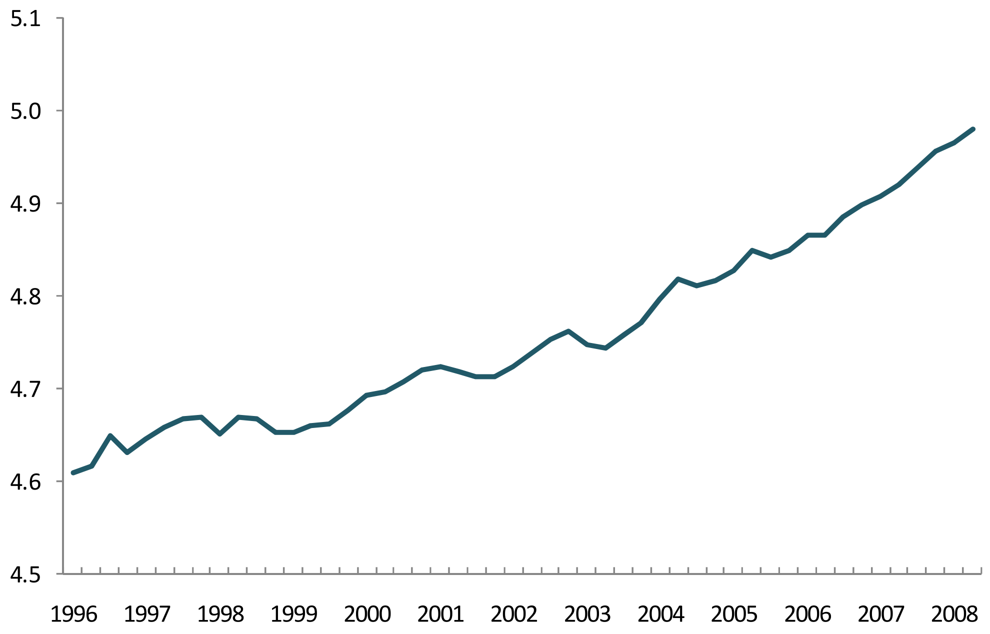

Figure A.1 – Final GDP (corresponding to the 2008Q2 vintage)

A.2. *Linear Trend (LT)*

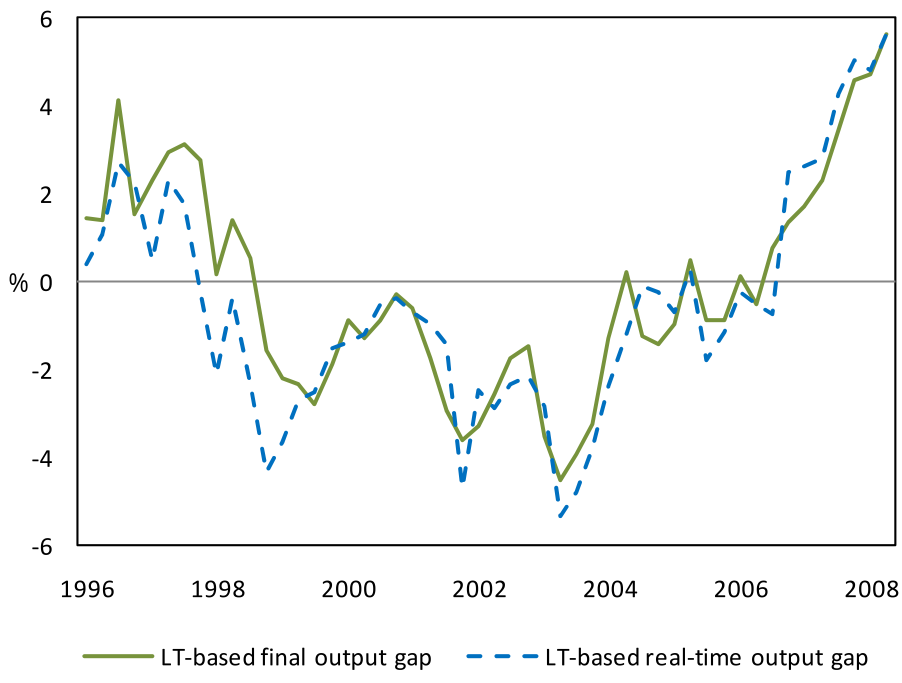

Figure A.2 – Final and real-time LT-based output gaps

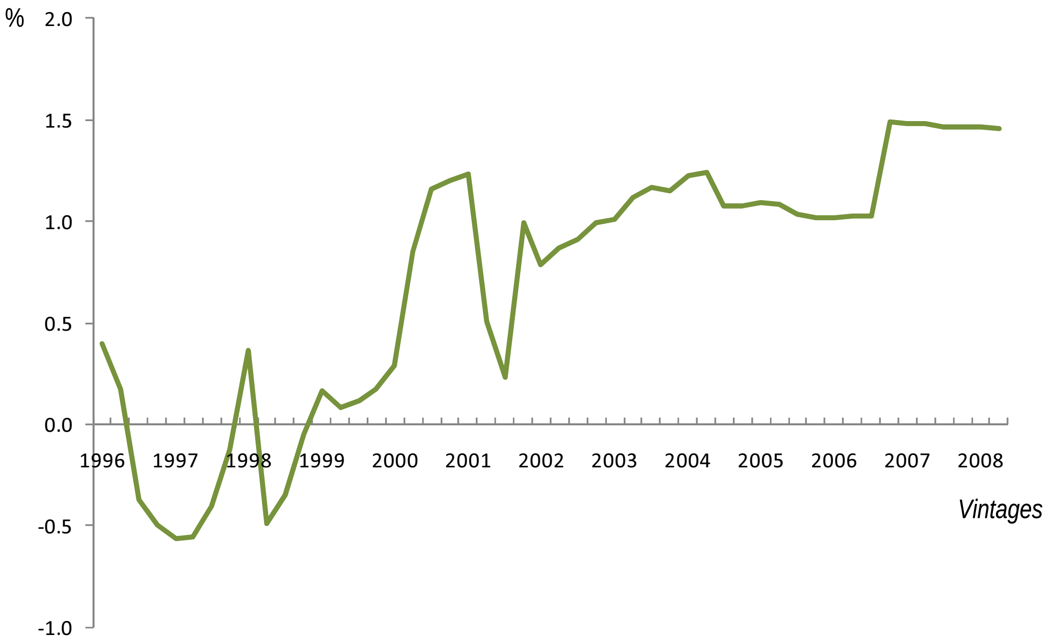

Figure A.3 – Output Gap (Linear Trend) of 1996Q1 over the revisions (% of GDP)

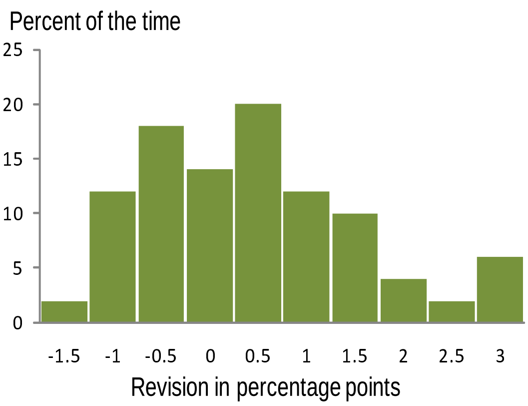

Figure A.4 – Relative frequency of the revisions of the LT-based output gap values

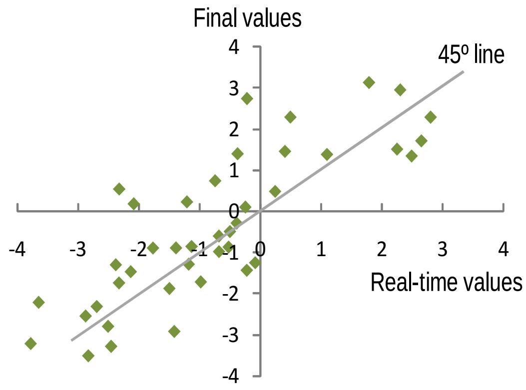

Figure A.5 – LT output gap values (real time *versus* final)

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

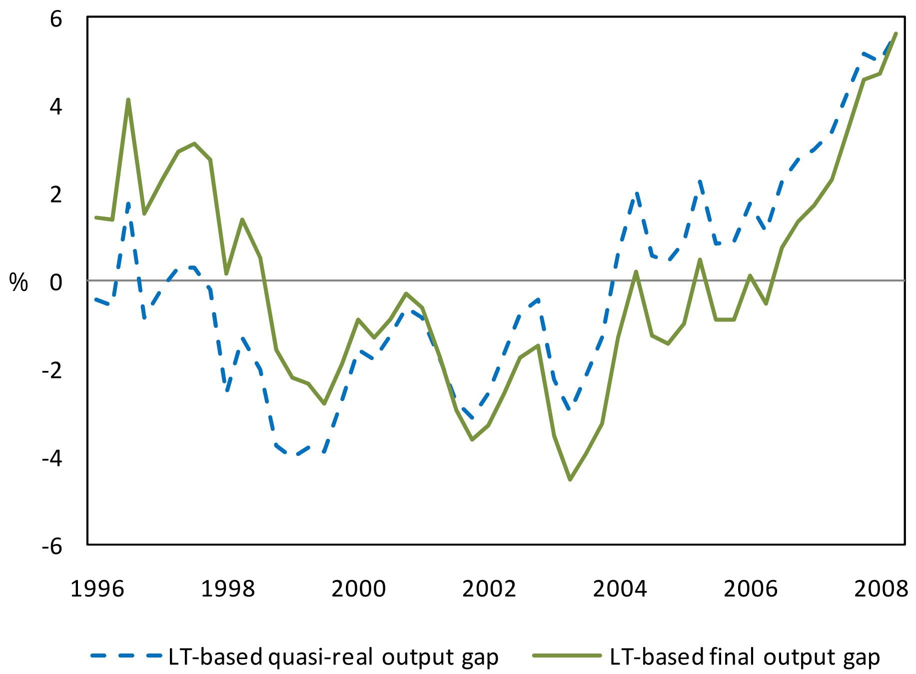

Figure A.7 – LT-based output gaps: Quasi-real and final series

A.3. *Quadratic Trend (QT)*

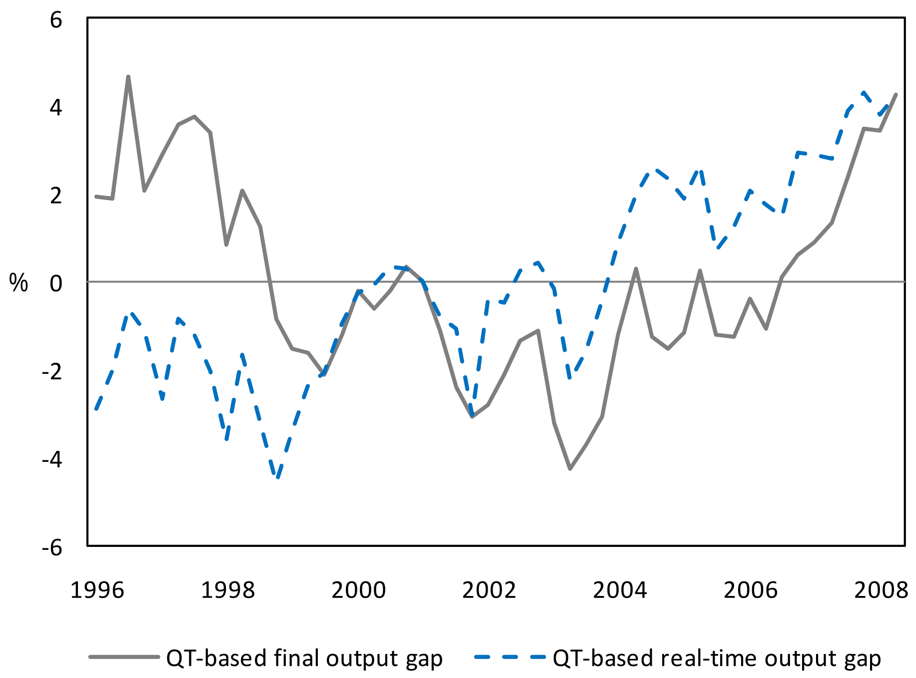

Figure A.8 – Final and real-time QT-based output gaps

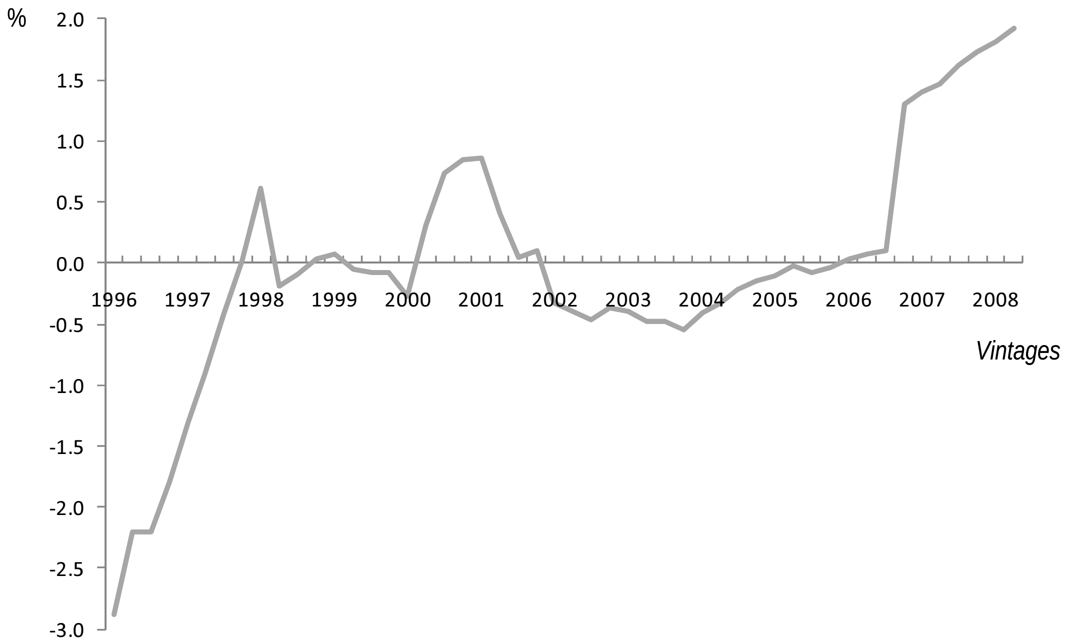

Figure A.9 – Output gap (Quadratic Trend) of 1996Q1 over the revisions (% of GDP)

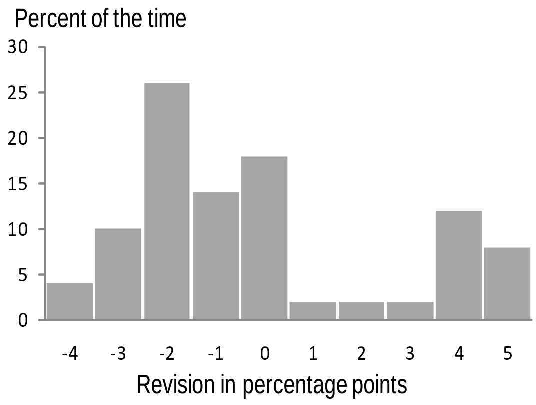

Figure A.10 – Relative frequency of the revisions of the QT-based output gap values

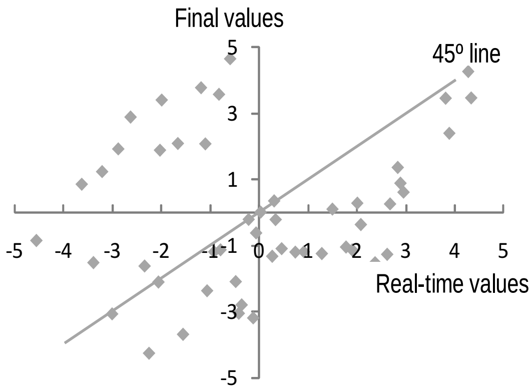

Figure A.11 – QT-based output gap values (real time *versus* final)

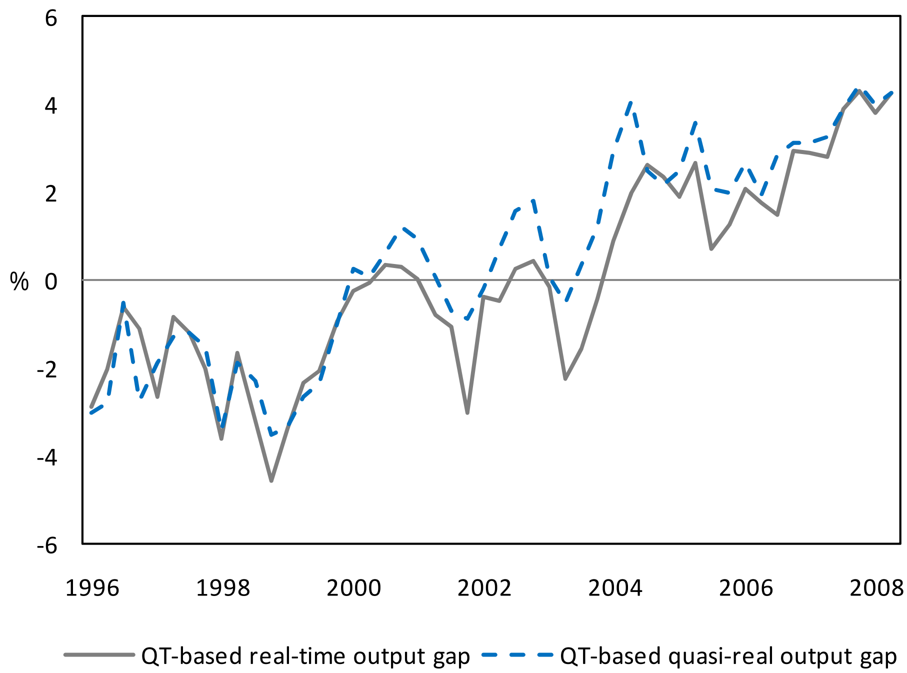

Figure A.12 –QT-based output gap – Real-time and quasi-real series

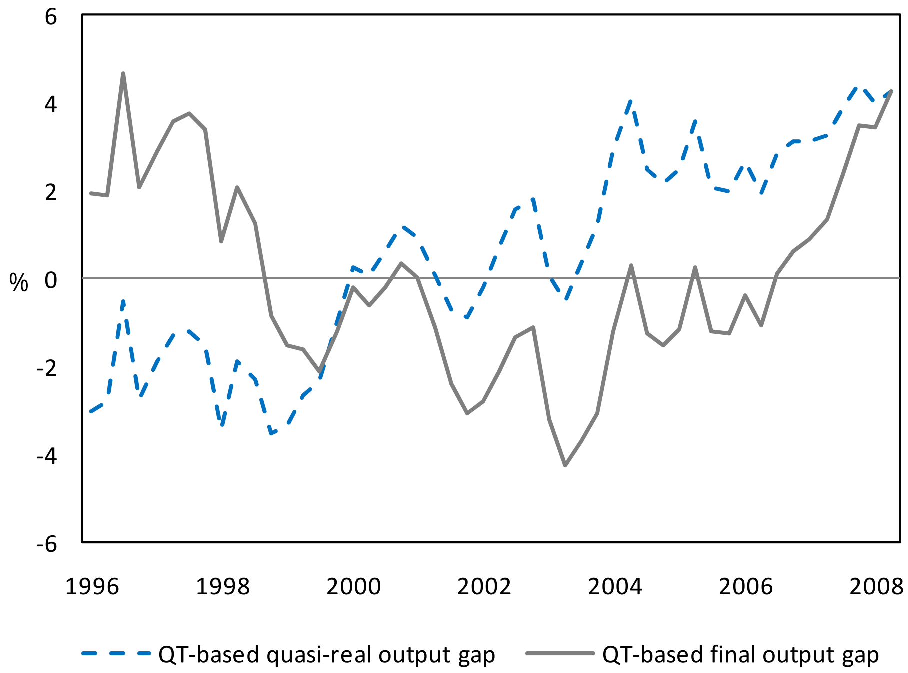

Figure A.13 – QT-based output gap – Quasi-real and final series

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

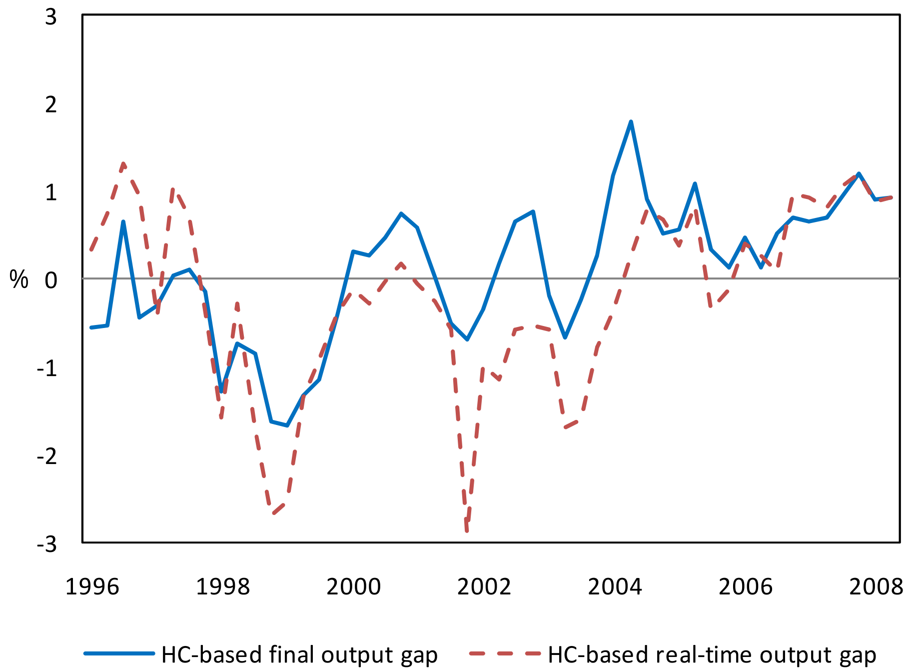

Figure A.14 – Final and real-time HC-based output gaps

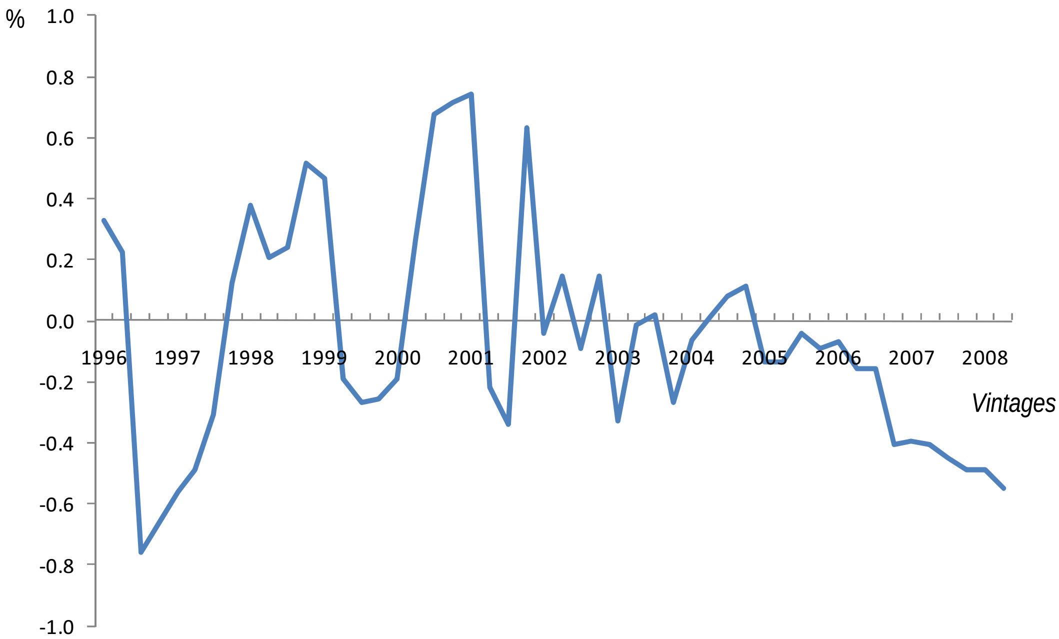

Figure A.15 – Output gap (Harvey-Clark) of 1996Q1 over the revisions (% of GDP)

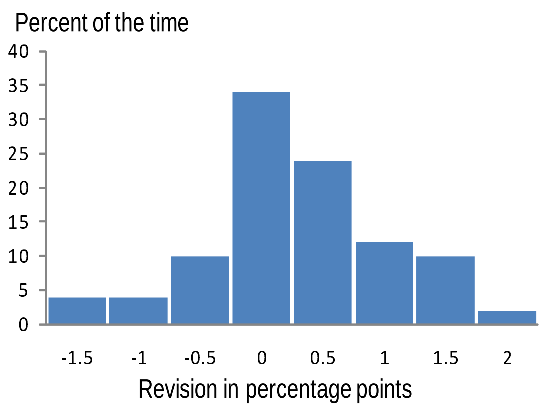

Figure A.16 – Relative frequency of the revision of the HC-based output gap values

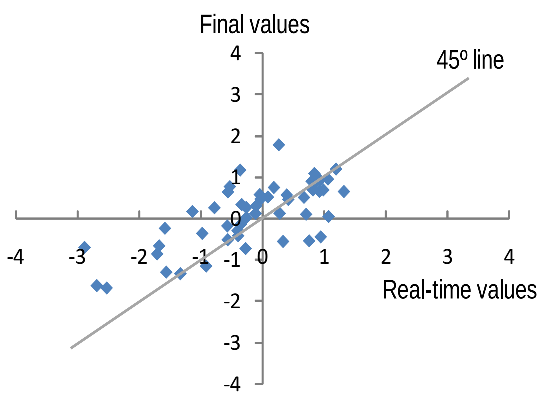

Figure A.17 – HC-based output gap values (real time *versus* final)

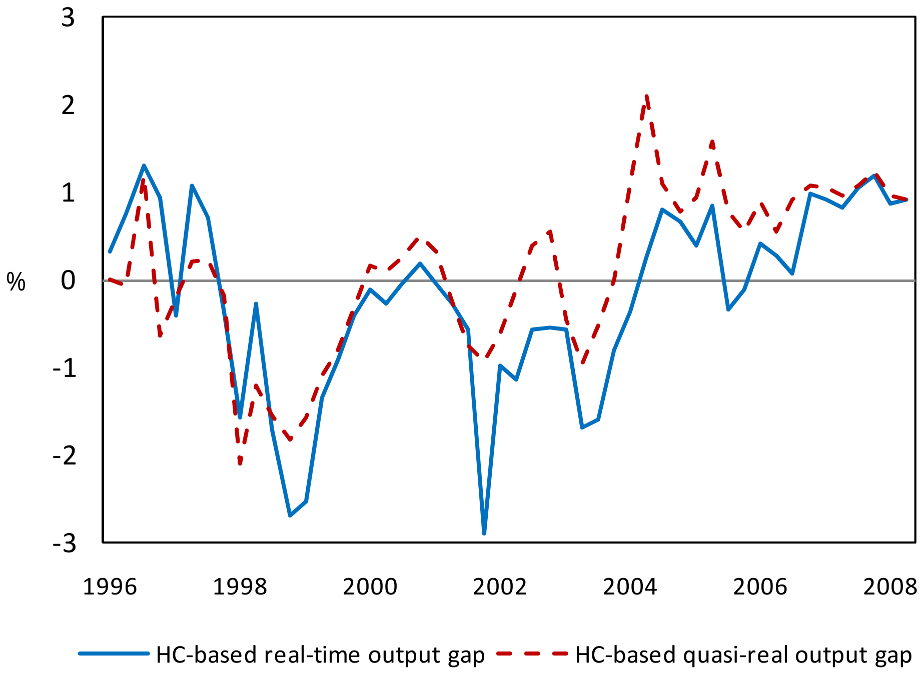

Figure A.18 – HC-based output gap values – Real-time and quasi-real series

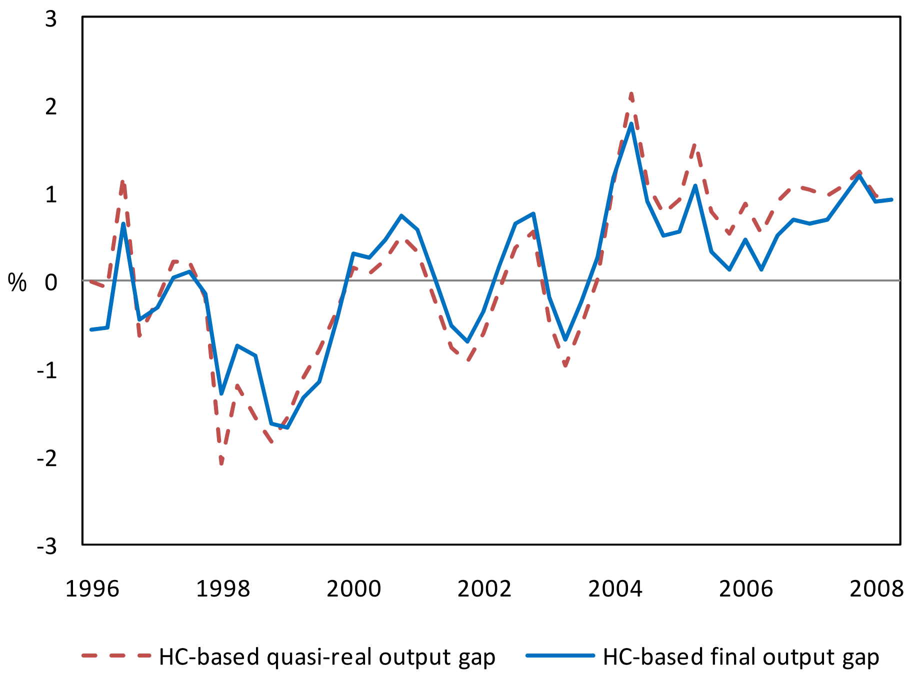

Figure A.19 – HC-based output gap values – Quasi-real and final series

Banco Central do Brasil

Trabalhos para Discussão

Os Trabalhos para Discussão podem ser acessados na internet, no formato PDF, no endereço: http://www.bc.gov.br

Working Paper Series

Working Papers in PDF format can be downloaded from: http://www.bc.gov.br

1	**Implementing Inflation Targeting in Brazil** *Joel Bogdanski, Alexandre Antonio Tombini and Sérgio Ribeiro da Costa Werlang*	Jul/2000
2	**Política Monetária e Supervisão do Sistema Financeiro Nacional no Banco Central do Brasil** *Eduardo Lundberg*	Jul/2000
	Monetary Policy and Banking Supervision Functions on the Central Bank *Eduardo Lundberg*	Jul/2000
3	**Private Sector Participation: a Theoretical Justification of the Brazilian Position** *Sérgio Ribeiro da Costa Werlang*	Jul/2000
4	**An Information Theory Approach to the Aggregation of Log-Linear Models** *Pedro H. Albuquerque*	Jul/2000
5	**The Pass-Through from Depreciation to Inflation: a Panel Study** *Ilan Goldfajn and Sérgio Ribeiro da Costa Werlang*	Jul/2000
6	**Optimal Interest Rate Rules in Inflation Targeting Frameworks** *José Alvaro Rodrigues Neto, Fabio Araújo and Marta Baltar J. Moreira*	Jul/2000
7	**Leading Indicators of Inflation for Brazil** *Marcelle Chauvet*	Sep/2000
8	**The Correlation Matrix of the Brazilian Central Bank's Standard Model for Interest Rate Market Risk** *José Alvaro Rodrigues Neto*	Sep/2000
9	**Estimating Exchange Market Pressure and Intervention Activity** *Emanuel-Werner Kohlscheen*	Nov/2000
10	**Análise do Financiamento Externo a uma Pequena Economia Aplicação da Teoria do Prêmio Monetário ao Caso Brasileiro: 1991–1998** *Carlos Hamilton Vasconcelos Araújo e Renato Galvão Flôres Júnior*	Mar/2001
11	**A Note on the Efficient Estimation of Inflation in Brazil** *Michael F. Bryan and Stephen G. Cecchetti*	Mar/2001
12	**A Test of Competition in Brazilian Banking** *Márcio I. Nakane*	Mar/2001

13	**Modelos de Previsão de Insolvência Bancária no Brasil** *Marcio Magalhães Janot*	Mar/2001
14	**Evaluating Core Inflation Measures for Brazil** *Francisco Marcos Rodrigues Figueiredo*	Mar/2001
15	**Is It Worth Tracking Dollar/Real Implied Volatility?** *Sandro Canesso de Andrade and Benjamin Miranda Tabak*	Mar/2001
16	**Avaliação das Projeções do Modelo Estrutural do Banco Central do Brasil para a Taxa de Variação do IPCA** *Sergio Afonso Lago Alves*	Mar/2001
	Evaluation of the Central Bank of Brazil Structural Model's Inflation Forecasts in an Inflation Targeting Framework *Sergio Afonso Lago Alves*	Jul/2001
17	**Estimando o Produto Potencial Brasileiro: uma Abordagem de Função de Produção** *Tito Nícias Teixeira da Silva Filho*	Abr/2001
	Estimating Brazilian Potential Output: a Production Function Approach *Tito Nícias Teixeira da Silva Filho*	Aug/2002
18	**A Simple Model for Inflation Targeting in Brazil** *Paulo Springer de Freitas and Marcelo Kfoury Muinhos*	Apr/2001
19	**Uncovered Interest Parity with Fundamentals: a Brazilian Exchange Rate Forecast Model** *Marcelo Kfoury Muinhos, Paulo Springer de Freitas and Fabio Araújo*	May/2001
20	**Credit Channel without the LM Curve** *Victorio Y. T. Chu and Márcio I. Nakane*	May/2001
21	**Os Impactos Econômicos da CPMF: Teoria e Evidência** *Pedro H. Albuquerque*	Jun/2001
22	**Decentralized Portfolio Management** *Paulo Coutinho and Benjamin Miranda Tabak*	Jun/2001
23	**Os Efeitos da CPMF sobre a Intermediação Financeira** *Sérgio Mikio Koyama e Márcio I. Nakane*	Jul/2001
24	**Inflation Targeting in Brazil: Shocks, Backward-Looking Prices, and IMF Conditionality** *Joel Bogdanski, Paulo Springer de Freitas, Ilan Goldfajn and Alexandre Antonio Tombini*	Aug/2001
25	**Inflation Targeting in Brazil: Reviewing Two Years of Monetary Policy 1999/00** *Pedro Fachada*	Aug/2001
26	**Inflation Targeting in an Open Financially Integrated Emerging Economy: the Case of Brazil** *Marcelo Kfoury Muinhos*	Aug/2001
27	**Complementaridade e Fungibilidade dos Fluxos de Capitais Internacionais** *Carlos Hamilton Vasconcelos Araújo e Renato Galvão Flôres Júnior*	Set/2001

28	**Regras Monetárias e Dinâmica Macroeconômica no Brasil: uma Abordagem de Expectativas Racionais** *Marco Antonio Bonomo e Ricardo D. Brito*	Nov/2001
29	**Using a Money Demand Model to Evaluate Monetary Policies in Brazil** *Pedro H. Albuquerque and Solange Gouvêa*	Nov/2001
30	**Testing the Expectations Hypothesis in the Brazilian Term Structure of Interest Rates** *Benjamin Miranda Tabak and Sandro Canesso de Andrade*	Nov/2001
31	**Algumas Considerações sobre a Sazonalidade no IPCA** *Francisco Marcos R. Figueiredo e Roberta Blass Staub*	Nov/2001
32	**Crises Cambiais e Ataques Especulativos no Brasil** *Mauro Costa Miranda*	Nov/2001
33	**Monetary Policy and Inflation in Brazil (1975-2000): a VAR Estimation** *André Minella*	Nov/2001
34	**Constrained Discretion and Collective Action Problems: Reflections on the Resolution of International Financial Crises** *Arminio Fraga and Daniel Luiz Gleizer*	Nov/2001
35	**Uma Definição Operacional de Estabilidade de Preços** *Tito Nícias Teixeira da Silva Filho*	Dez/2001
36	**Can Emerging Markets Float? Should They Inflation Target?** *Barry Eichengreen*	Feb/2002
37	**Monetary Policy in Brazil: Remarks on the Inflation Targeting Regime, Public Debt Management and Open Market Operations** *Luiz Fernando Figueiredo, Pedro Fachada and Sérgio Goldenstein*	Mar/2002
38	**Volatilidade Implícita e Antecipação de Eventos de *Stress*: um Teste para o Mercado Brasileiro** *Frederico Pechir Gomes*	Mar/2002
39	**Opções sobre Dólar Comercial e Expectativas a Respeito do Comportamento da Taxa de Câmbio** *Paulo Castor de Castro*	Mar/2002
40	**Speculative Attacks on Debts, Dollarization and Optimum Currency Areas** *Aloisio Araujo and Márcia Leon*	Apr/2002
41	**Mudanças de Regime no Câmbio Brasileiro** *Carlos Hamilton V. Araújo e Getúlio B. da Silveira Filho*	Jun/2002
42	**Modelo Estrutural com Setor Externo: Endogenização do Prêmio de Risco e do Câmbio** *Marcelo Kfoury Muinhos, Sérgio Afonso Lago Alves e Gil Riella*	Jun/2002
43	**The Effects of the Brazilian ADRs Program on Domestic Market Efficiency** *Benjamin Miranda Tabak and Eduardo José Araújo Lima*	Jun/2002

44	**Estrutura Competitiva, Produtividade Industrial e Liberação Comercial no Brasil** *Pedro Cavalcanti Ferreira e Osmani Teixeira de Carvalho Guillén*	Jun/2002
45	**Optimal Monetary Policy, Gains from Commitment, and Inflation Persistence** *André Minella*	Aug/2002
46	**The Determinants of Bank Interest Spread in Brazil** *Tarsila Segalla Afanasieff, Priscilla Maria Villa Lhacer and Márcio I. Nakane*	Aug/2002
47	**Indicadores Derivados de Agregados Monetários** *Fernando de Aquino Fonseca Neto e José Albuquerque Júnior*	Set/2002
48	**Should Government Smooth Exchange Rate Risk?** *Ilan Goldfajn and Marcos Antonio Silveira*	Sep/2002
49	**Desenvolvimento do Sistema Financeiro e Crescimento Econômico no Brasil: Evidências de Causalidade** *Orlando Carneiro de Matos*	Set/2002
50	**Macroeconomic Coordination and Inflation Targeting in a Two-Country Model** *Eui Jung Chang, Marcelo Kfoury Muinhos and Joanílio Rodolpho Teixeira*	Sep/2002
51	**Credit Channel with Sovereign Credit Risk: an Empirical Test** *Victorio Yi Tson Chu*	Sep/2002
52	**Generalized Hyperbolic Distributions and Brazilian Data** *José Fajardo and Aquiles Farias*	Sep/2002
53	**Inflation Targeting in Brazil: Lessons and Challenges** *André Minella, Paulo Springer de Freitas, Ilan Goldfajn and Marcelo Kfoury Muinhos*	Nov/2002
54	**Stock Returns and Volatility** *Benjamin Miranda Tabak and Solange Maria Guerra*	Nov/2002
55	**Componentes de Curto e Longo Prazo das Taxas de Juros no Brasil** *Carlos Hamilton Vasconcelos Araújo e Osmani Teixeira de Carvalho de Guillén*	Nov/2002
56	**Causality and Cointegration in Stock Markets: the Case of Latin America** *Benjamin Miranda Tabak and Eduardo José Araújo Lima*	Dec/2002
57	**As Leis de Falência: uma Abordagem Econômica** *Aloisio Araujo*	Dez/2002
58	**The Random Walk Hypothesis and the Behavior of Foreign Capital Portfolio Flows: the Brazilian Stock Market Case** *Benjamin Miranda Tabak*	Dec/2002
59	**Os Preços Administrados e a Inflação no Brasil** *Francisco Marcos R. Figueiredo e Thaís Porto Ferreira*	Dez/2002
60	**Delegated Portfolio Management** *Paulo Coutinho and Benjamin Miranda Tabak*	Dec/2002

61	**O Uso de Dados de Alta Freqüência na Estimação da Volatilidade e do Valor em Risco para o Ibovespa** *João Maurício de Souza Moreira e Eduardo Facó Lemgruber*	Dez/2002
62	**Taxa de Juros e Concentração Bancária no Brasil** *Eduardo Kiyoshi Tonooka e Sérgio Mikio Koyama*	Fev/2003
63	**Optimal Monetary Rules: the Case of Brazil** *Charles Lima de Almeida, Marco Aurélio Peres, Geraldo da Silva e Souza and Benjamin Miranda Tabak*	Feb/2003
64	**Medium-Size Macroeconomic Model for the Brazilian Economy** *Marcelo Kfoury Muinhos and Sergio Afonso Lago Alves*	Feb/2003
65	**On the Information Content of Oil Future Prices** *Benjamin Miranda Tabak*	Feb/2003
66	**A Taxa de Juros de Equilíbrio: uma Abordagem Múltipla** *Pedro Calhman de Miranda e Marcelo Kfoury Muinhos*	Fev/2003
67	**Avaliação de Métodos de Cálculo de Exigência de Capital para Risco de Mercado de Carteiras de Ações no Brasil** *Gustavo S. Araújo, João Maurício S. Moreira e Ricardo S. Maia Clemente*	Fev/2003
68	**Real Balances in the Utility Function: Evidence for Brazil** *Leonardo Soriano de Alencar and Márcio I. Nakane*	Feb/2003
69	**r-filters: a Hodrick-Prescott Filter Generalization** *Fabio Araújo, Marta Baltar Moreira Areosa and José Alvaro Rodrigues Neto*	Feb/2003
70	**Monetary Policy Surprises and the Brazilian Term Structure of Interest Rates** *Benjamin Miranda Tabak*	Feb/2003
71	**On Shadow-Prices of Banks in Real-Time Gross Settlement Systems** *Rodrigo Penaloza*	Apr/2003
72	**O Prêmio pela Maturidade na Estrutura a Termo das Taxas de Juros Brasileiras** *Ricardo Dias de Oliveira Brito, Angelo J. Mont'Alverne Duarte e Osmani Teixeira de C. Guillen*	Maio/2003
73	**Análise de Componentes Principais de Dados Funcionais – uma Aplicação às Estruturas a Termo de Taxas de Juros** *Getúlio Borges da Silveira e Octavio Bessada*	Maio/2003
74	**Aplicação do Modelo de Black, Derman & Toy à Precificação de Opções Sobre Títulos de Renda Fixa** *Octavio Manuel Bessada Lion, Carlos Alberto Nunes Cosenza e César das Neves*	Maio/2003
75	**Brazil’s Financial System: Resilience to Shocks, no Currency Substitution, but Struggling to Promote Growth** *Ilan Goldfajn, Katherine Hennings and Helio Mori*	Jun/2003

76 **Inflation Targeting in Emerging Market Economies** Jun/2003
Arminio Fraga, Ilan Goldfajn and André Minella

77 **Inflation Targeting in Brazil: Constructing Credibility under Exchange Rate Volatility** Jul/2003
André Minella, Paulo Springer de Freitas, Ilan Goldfajn and Marcelo Kfoury Muinhos

78 **Contornando os Pressupostos de Black & Scholes: Aplicação do Modelo de Precificação de Opções de Duan no Mercado Brasileiro** Out/2003
Gustavo Silva Araújo, Claudio Henrique da Silveira Barbedo, Antonio Carlos Figueiredo, Eduardo Facó Lemgruber

79 **Inclusão do Decaimento Temporal na Metodologia Delta-Gama para o Cálculo do VaR de Carteiras Compradas em Opções no Brasil** Out/2003
Claudio Henrique da Silveira Barbedo, Gustavo Silva Araújo, Eduardo Facó Lemgruber

80 **Diferenças e Semelhanças entre Países da América Latina: uma Análise de *Markov Switching* para os Ciclos Econômicos de Brasil e Argentina** Out/2003
Arnildo da Silva Correa

81 **Bank Competition, Agency Costs and the Performance of the Monetary Policy** Jan/2004
Leonardo Soriano de Alencar and Márcio I. Nakane

82 **Carteiras de Opções: Avaliação de Metodologias de Exigência de Capital no Mercado Brasileiro** Mar/2004
Cláudio Henrique da Silveira Barbedo e Gustavo Silva Araújo

83 **Does Inflation Targeting Reduce Inflation? An Analysis for the OECD Industrial Countries** May/2004
Thomas Y. Wu

84 **Speculative Attacks on Debts and Optimum Currency Area: a Welfare Analysis** May/2004
Aloisio Araujo and Marcia Leon

85 **Risk Premia for Emerging Markets Bonds: Evidence from Brazilian Government Debt, 1996-2002** May/2004
André Soares Loureiro and Fernando de Holanda Barbosa

86 **Identificação do Fator Estocástico de Descontos e Algumas Implicações sobre Testes de Modelos de Consumo** Maio/2004
Fabio Araujo e João Victor Issler

87 **Mercado de Crédito: uma Análise Econométrica dos Volumes de Crédito Total e Habitacional no Brasil** Dez/2004
Ana Carla Abrão Costa

88 **Ciclos Internacionais de Negócios: uma Análise de Mudança de Regime Markoviano para Brasil, Argentina e Estados Unidos** Dez/2004
Arnildo da Silva Correa e Ronald Otto Hillbrecht

89 **O Mercado de *Hedge* Cambial no Brasil: Reação das Instituições Financeiras a Intervenções do Banco Central** Dez/2004
Fernando N. de Oliveira

90	**Bank Privatization and Productivity: Evidence for Brazil** *Márcio I. Nakane and Daniela B. Weintraub*	Dec/2004
91	**Credit Risk Measurement and the Regulation of Bank Capital and Provision Requirements in Brazil – a Corporate Analysis** *Ricardo Schechtman, Valéria Salomão Garcia, Sergio Mikio Koyama and Guilherme Cronemberger Parente*	Dec/2004
92	**Steady-State Analysis of an Open Economy General Equilibrium Model for Brazil** *Mirta Noemi Sataka Bugarin, Roberto de Goes Ellery Jr., Victor Gomes Silva, Marcelo Kfoury Muinhos*	Apr/2005
93	**Avaliação de Modelos de Cálculo de Exigência de Capital para Risco Cambial** *Claudio H. da S. Barbedo, Gustavo S. Araújo, João Maurício S. Moreira e Ricardo S. Maia Clemente*	Abr/2005
94	**Simulação Histórica Filtrada: Incorporação da Volatilidade ao Modelo Histórico de Cálculo de Risco para Ativos Não-Lineares** *Claudio Henrique da Silveira Barbedo, Gustavo Silva Araújo e Eduardo Facó Lemgruber*	Abr/2005
95	**Comment on Market Discipline and Monetary Policy by Carl Walsh** *Maurício S. Bugarin and Fábia A. de Carvalho*	Apr/2005
96	**O que É Estratégia: uma Abordagem Multiparadigmática para a Disciplina** *Anthero de Moraes Meirelles*	Ago/2005
97	**Finance and the Business Cycle: a Kalman Filter Approach with Markov Switching** *Ryan A. Compton and Jose Ricardo da Costa e Silva*	Aug/2005
98	**Capital Flows Cycle: Stylized Facts and Empirical Evidences for Emerging Market Economies** *Helio Mori e Marcelo Kfoury Muinhos*	Aug/2005
99	**Adequação das Medidas de Valor em Risco na Formulação da Exigência de Capital para Estratégias de Opções no Mercado Brasileiro** *Gustavo Silva Araújo, Claudio Henrique da Silveira Barbedo,e Eduardo Facó Lemgruber*	Set/2005
100	**Targets and Inflation Dynamics** *Sergio A. L. Alves and Waldyr D. Areosa*	Oct/2005
101	**Comparing Equilibrium Real Interest Rates: Different Approaches to Measure Brazilian Rates** *Marcelo Kfoury Muinhos and Márcio I. Nakane*	Mar/2006
102	**Judicial Risk and Credit Market Performance: Micro Evidence from Brazilian Payroll Loans** *Ana Carla A. Costa and João M. P. de Mello*	Apr/2006
103	**The Effect of Adverse Supply Shocks on Monetary Policy and Output** *Maria da Glória D. S. Araújo, Mirta Bugarin, Marcelo Kfoury Muinhos and Jose Ricardo C. Silva*	Apr/2006

104	**Extração de Informação de Opções Cambiais no Brasil** *Eui Jung Chang e Benjamin Miranda Tabak*	Abr/2006
105	**Representing Roommate's Preferences with Symmetric Utilities** *José Alvaro Rodrigues Neto*	Apr/2006
106	**Testing Nonlinearities Between Brazilian Exchange Rates and Inflation Volatilities** *Cristiane R. Albuquerque and Marcelo Portugal*	May/2006
107	**Demand for Bank Services and Market Power in Brazilian Banking** *Márcio I. Nakane, Leonardo S. Alencar and Fabio Kanczuk*	Jun/2006
108	**O Efeito da Consignação em Folha nas Taxas de Juros dos Empréstimos Pessoais** *Eduardo A. S. Rodrigues, Victorio Chu, Leonardo S. Alencar e Tony Takeda*	Jun/2006
109	**The Recent Brazilian Disinflation Process and Costs** *Alexandre A. Tombini and Sergio A. Lago Alves*	Jun/2006
110	**Fatores de Risco e o *Spread* Bancário no Brasil** *Fernando G. Bignotto e Eduardo Augusto de Souza Rodrigues*	Jul/2006
111	**Avaliação de Modelos de Exigência de Capital para Risco de Mercado do Cupom Cambial** *Alan Cosme Rodrigues da Silva, João Maurício de Souza Moreira e Myrian Beatriz Eiras das Neves*	Jul/2006
112	**Interdependence and Contagion: an Analysis of Information Transmission in Latin America's Stock Markets** *Angelo Marsiglia Fasolo*	Jul/2006
113	**Investigação da Memória de Longo Prazo da Taxa de Câmbio no Brasil** *Sergio Rubens Stancato de Souza, Benjamin Miranda Tabak e Daniel O. Cajueiro*	Ago/2006
114	**The Inequality Channel of Monetary Transmission** *Marta Areosa and Waldyr Areosa*	Aug/2006
115	**Myopic Loss Aversion and House-Money Effect Overseas: an Experimental Approach** *José L. B. Fernandes, Juan Ignacio Peña and Benjamin M. Tabak*	Sep/2006
116	**Out-Of-The-Money Monte Carlo Simulation Option Pricing: the Join Use of Importance Sampling and Descriptive Sampling** *Jaqueline Terra Moura Marins, Eduardo Saliby and Joséte Florencio dos Santos*	Sep/2006
117	**An Analysis of Off-Site Supervision of Banks' Profitability, Risk and Capital Adequacy: a Portfolio Simulation Approach Applied to Brazilian Banks** *Theodore M. Barnhill, Marcos R. Souto and Benjamin M. Tabak*	Sep/2006
118	**Contagion, Bankruptcy and Social Welfare Analysis in a Financial Economy with Risk Regulation Constraint** *Aloísio P. Araújo and José Valentim M. Vicente*	Oct/2006

119	**A Central de Risco de Crédito no Brasil: uma Análise de Utilidade de Informação** *Ricardo Schechtman*	Out/2006
120	**Forecasting Interest Rates: an Application for Brazil** *Eduardo J. A. Lima, Felipe Luduvice and Benjamin M. Tabak*	Oct/2006
121	**The Role of Consumer's Risk Aversion on Price Rigidity** *Sergio A. Lago Alves and Mirta N. S. Bugarin*	Nov/2006
122	**Nonlinear Mechanisms of the Exchange Rate Pass-Through: a Phillips Curve Model With Threshold for Brazil** *Arnildo da Silva Correa and André Minella*	Nov/2006
123	**A Neoclassical Analysis of the Brazilian "Lost-Decades"** *Flávia Mourão Graminho*	Nov/2006
124	**The Dynamic Relations between Stock Prices and Exchange Rates: Evidence for Brazil** *Benjamin M. Tabak*	Nov/2006
125	**Herding Behavior by Equity Foreign Investors on Emerging Markets** *Barbara Alemanni and José Renato Haas Ornelas*	Dec/2006
126	**Risk Premium: Insights over the Threshold** *José L. B. Fernandes, Augusto Hasman and Juan Ignacio Peña*	Dec/2006
127	**Uma Investigação Baseada em Reamostragem sobre Requerimentos de Capital para Risco de Crédito no Brasil** *Ricardo Schechtman*	Dec/2006
128	**Term Structure Movements Implicit in Option Prices** *Caio Ibsen R. Almeida and José Valentim M. Vicente*	Dec/2006
129	**Brazil: Taming Inflation Expectations** *Afonso S. Bevilaqua, Mário Mesquita and André Minella*	Jan/2007
130	**The Role of Banks in the Brazilian Interbank Market: Does Bank Type Matter?** *Daniel O. Cajueiro and Benjamin M. Tabak*	Jan/2007
131	**Long-Range Dependence in Exchange Rates: the Case of the European Monetary System** *Sergio Rubens Stancato de Souza, Benjamin M. Tabak and Daniel O. Cajueiro*	Mar/2007
132	**Credit Risk Monte Carlo Simulation Using Simplified Creditmetrics' Model: the Joint Use of Importance Sampling and Descriptive Sampling** *Jaqueline Terra Moura Marins and Eduardo Saliby*	Mar/2007
133	**A New Proposal for Collection and Generation of Information on Financial Institutions' Risk: the Case of Derivatives** *Gilneu F. A. Vivan and Benjamin M. Tabak*	Mar/2007
134	**Amostragem Descritiva no Apreçamento de Opções Européias através de Simulação Monte Carlo: o Efeito da Dimensionalidade e da Probabilidade de Exercício no Ganho de Precisão** *Eduardo Saliby, Sergio Luiz Medeiros Proença de Gouvêa e Jaqueline Terra Moura Marins*	Abr/2007

135	**Evaluation of Default Risk for the Brazilian Banking Sector** *Marcelo Y. Takami and Benjamin M. Tabak*	May/2007
136	**Identifying Volatility Risk Premium from Fixed Income Asian Options** *Caio Ibsen R. Almeida and José Valentim M. Vicente*	May/2007
137	**Monetary Policy Design under Competing Models of Inflation Persistence** *Solange Gouvea e Abhijit Sen Gupta*	May/2007
138	**Forecasting Exchange Rate Density Using Parametric Models: the Case of Brazil** *Marcos M. Abe, Eui J. Chang and Benjamin M. Tabak*	May/2007
139	**Selection of Optimal Lag Length inCointegrated VAR Models with Weak Form of Common Cyclical Features** *Carlos Enrique Carrasco Gutiérrez, Reinaldo Castro Souza and Osmani Teixeira de Carvalho Guillén*	Jun/2007
140	**Inflation Targeting, Credibility and Confidence Crises** *Rafael Santos and Aloísio Araújo*	Aug/2007
141	**Forecasting Bonds Yields in the Brazilian Fixed income Market** *Jose Vicente and Benjamin M. Tabak*	Aug/2007
142	**Crises Análise da Coerência de Medidas de Risco no Mercado Brasileiro de Ações e Desenvolvimento de uma Metodologia Híbrida para o *Expected Shortfall*** *Alan Cosme Rodrigues da Silva, Eduardo Facó Lemgruber, José Alberto Rebello Baranowski e Renato da Silva Carvalho*	Ago/2007
143	**Price Rigidity in Brazil: Evidence from CPI Micro Data** *Solange Gouvea*	Sep/2007
144	**The Effect of Bid-Ask Prices on Brazilian Options Implied Volatility: a Case Study of Telemar Call Options** *Claudio Henrique da Silveira Barbedo and Eduardo Facó Lemgruber*	Oct/2007
145	**The Stability-Concentration Relationship in the Brazilian Banking System** *Benjamin Miranda Tabak, Solange Maria Guerra, Eduardo José Araújo Lima and Eui Jung Chang*	Oct/2007
146	**Movimentos da Estrutura a Termo e Critérios de Minimização do Erro de Previsão em um Modelo Paramétrico Exponencial** *Caio Almeida, Romeu Gomes, André Leite e José Vicente*	Out/2007
147	**Explaining Bank Failures in Brazil: Micro, Macro and Contagion Effects (1994-1998)** *Adriana Soares Sales and Maria Eduarda Tannuri-Pianto*	Oct/2007
148	**Um Modelo de Fatores Latentes com Variáveis Macroeconômicas para a Curva de Cupom Cambial** *Felipe Pinheiro, Caio Almeida e José Vicente*	Out/2007
149	**Joint Validation of Credit Rating PDs under Default Correlation** *Ricardo Schechtman*	Oct/2007

150	**A Probabilistic Approach for Assessing the Significance of Contextual Variables in Nonparametric Frontier Models: an Application for Brazilian Banks** *Roberta Blass Staub and Geraldo da Silva e Souza*	Oct/2007
151	**Building Confidence Intervals with Block Bootstraps for the Variance Ratio Test of Predictability** *Eduardo José Araújo Lima and Benjamin Miranda Tabak*	Nov/2007
152	**Demand for Foreign Exchange Derivatives in Brazil: Hedge or Speculation?** *Fernando N. de Oliveira and Walter Novaes*	Dec/2007
153	**Aplicação da Amostragem por Importância à Simulação de Opções Asiáticas Fora do Dinheiro** *Jaqueline Terra Moura Marins*	Dez/2007
154	**Identification of Monetary Policy Shocks in the Brazilian Market for Bank Reserves** *Adriana Soares Sales and Maria Tannuri-Pianto*	Dec/2007
155	**Does Curvature Enhance Forecasting?** *Caio Almeida, Romeu Gomes, André Leite and José Vicente*	Dec/2007
156	**Escolha do Banco e Demanda por Empréstimos: um Modelo de Decisão em Duas Etapas Aplicado para o Brasil** *Sérgio Mikio Koyama e Márcio I. Nakane*	Dez/2007
157	**Is the Investment-Uncertainty Link Really Elusive? The Harmful Effects of Inflation Uncertainty in Brazil** *Tito Nícias Teixeira da Silva Filho*	Jan/2008
158	**Characterizing the Brazilian Term Structure of Interest Rates** *Osmani T. Guillen and Benjamin M. Tabak*	Feb/2008
159	**Behavior and Effects of Equity Foreign Investors on Emerging Markets** *Barbara Alemanni and José Renato Haas Ornelas*	Feb/2008
160	**The Incidence of Reserve Requirements in Brazil: Do Bank Stockholders Share the Burden?** *Fábia A. de Carvalho and Cyntia F. Azevedo*	Feb/2008
161	**Evaluating Value-at-Risk Models via Quantile Regressions** *Wagner P. Gaglianone, Luiz Renato Lima and Oliver Linton*	Feb/2008
162	**Balance Sheet Effects in Currency Crises: Evidence from Brazil** *Marcio M. Janot, Márcio G. P. Garcia and Walter Novaes*	Apr/2008
163	**Searching for the Natural Rate of Unemployment in a Large Relative Price Shocks' Economy: the Brazilian Case** *Tito Nícias Teixeira da Silva Filho*	May/2008
164	**Foreign Banks' Entry and Departure: the recent Brazilian experience (1996-2006)** *Pedro Fachada*	Jun/2008
165	**Avaliação de Opções de Troca e Opções de *Spread* Européias e Americanas** *Giuliano Carrozza Uzêda Iorio de Souza, Carlos Patrício Samanez e Gustavo Santos Raposo*	Jul/2008

166	**Testing Hyperinflation Theories Using the Inflation Tax Curve: a case study** *Fernando de Holanda Barbosa and Tito Nícias Teixeira da Silva Filho*	Jul/2008
167	**O Poder Discriminante das Operações de Crédito das Instituições Financeiras Brasileiras** *Clodoaldo Aparecido Annibal*	Jul/2008
168	**An Integrated Model for Liquidity Management and Short-Term Asset Allocation in Commercial Banks** *Wenersamy Ramos de Alcântara*	Jul/2008
169	**Mensuração do Risco Sistêmico no Setor Bancário com Variáveis Contábeis e Econômicas** *Lucio Rodrigues Capelletto, Eliseu Martins e Luiz João Corrar*	Jul/2008
170	**Política de Fechamento de Bancos com Regulador Não-Benevolente: Resumo e Aplicação** *Adriana Soares Sales*	Jul/2008
171	**Modelos para a Utilização das Operações de Redesconto pelos Bancos com Carteira Comercial no Brasil** *Sérgio Mikio Koyama e Márcio Issao Nakane*	Ago/2008
172	**Combining Hodrick-Prescott Filtering with a Production Function Approach to Estimate Output Gap** *Marta Areosa*	Aug/2008
173	**Exchange Rate Dynamics and the Relationship between the Random Walk Hypothesis and Official Interventions** *Eduardo José Araújo Lima and Benjamin Miranda Tabak*	Aug/2008
174	**Foreign Exchange Market Volatility Information: an investigation of real-dollar exchange rate** *Frederico Pechir Gomes, Marcelo Yoshio Takami and Vinicius Ratton Brandi*	Aug/2008
175	**Evaluating Asset Pricing Models in a Fama-French Framework** *Carlos Enrique Carrasco Gutierrez and Wagner Piazza Gaglianone*	Dec/2008
176	**Fiat Money and the Value of Binding Portfolio Constraints** *Mário R. Páscoa, Myrian Petrassi and Juan Pablo Torres-Martínez*	Dec/2008
177	**Preference for Flexibility and Bayesian Updating** *Gil Riella*	Dec/2008
178	**An Econometric Contribution to the Intertemporal Approach of the Current Account** *Wagner Piazza Gaglianone and João Victor Issler*	Dec/2008
179	**Are Interest Rate Options Important for the Assessment of Interest Rate Risk?** *Caio Almeida and José Vicente*	Dec/2008
180	**A Class of Incomplete and Ambiguity Averse Preferences** *Leandro Nascimento and Gil Riella*	Dec/2008
181	**Monetary Channels in Brazil through the Lens of a Semi-Structural Model** *André Minella and Nelson F. Souza-Sobrinho*	Apr/2009

182	**Avaliação de Opções Americanas com Barreiras Monitoradas de Forma Discreta** *Giuliano Carrozza Uzêda Iorio de Souza e Carlos Patrício Samanez*	Abr/2009
183	**Ganhos da Globalização do Capital Acionário em Crises Cambiais** *Marcio Janot e Walter Novaes*	Abr/2009
184	**Behavior Finance and Estimation Risk in Stochastic Portfolio Optimization** *José Luiz Barros Fernandes, Juan Ignacio Peña and Benjamin Miranda Tabak*	Apr/2009
185	**Market Forecasts in Brazil: performance and determinants** *Fabia A. de Carvalho and André Minella*	Apr/2009
186	**Previsão da Curva de Juros: um modelo estatístico com variáveis macroeconômicas** *André Luís Leite, Romeu Braz Pereira Gomes Filho e José Valentim Machado Vicente*	Maio/2009
187	**The Influence of Collateral on Capital Requirements in the Brazilian Financial System: an approach through historical average and logistic regression on probability of default** *Alan Cosme Rodrigues da Silva, Antônio Carlos Magalhães da Silva, Jaqueline Terra Moura Marins, Myrian Beatriz Eiras da Neves and Giovani Antonio Silva Brito*	Jun/2009
188	**Pricing Asian Interest Rate Options with a Three-Factor HJM Model** *Claudio Henrique da Silveira Barbedo, José Valentim Machado Vicente and Octávio Manuel Bessada Lion*	Jun/2009
189	**Linking Financial and Macroeconomic Factors to Credit Risk Indicators of Brazilian Banks** *Marcos Souto, Benjamin M. Tabak and Francisco Vazquez*	Jul/2009
190	**Concentração Bancária, Lucratividade e Risco Sistêmico: uma abordagem de contágio indireto** *Bruno Silva Martins e Leonardo S. Alencar*	Set/2009
191	**Concentração e Inadimplência nas Carteiras de Empréstimos dos Bancos Brasileiros** *Patricia L. Tecles, Benjamin M. Tabak e Roberta B. Staub*	Set/2009
192	**Inadimplência do Setor Bancário Brasileiro: uma avaliação de suas medidas** *Clodoaldo Aparecido Annibal*	Set/2009
193	***Loss Given Default*: um estudo sobre perdas em operações prefixadas no mercado brasileiro** *Antonio Carlos Magalhães da Silva, Jaqueline Terra Moura Marins e Myrian Beatriz Eiras das Neves*	Set/2009
194	**Testes de Contágio entre Sistemas Bancários – A crise do *subprime*** *Benjamin M. Tabak e Manuela M. de Souza*	Set/2009
195	**From Default Rates to Default Matrices: a complete measurement of Brazilian banks' consumer credit delinquency** *Ricardo Schechtman*	Oct/2009

196	**The role of macroeconomic variables in sovereign risk** *Marco S. Matsumura and José Valentim Vicente*	Oct/2009
197	**Forecasting the Yield Curve for Brazil** *Daniel O. Cajueiro, Jose A. Divino and Benjamin M. Tabak*	Nov/2009
198	**Impacto dos *Swaps* Cambiais na Curva de Cupom Cambial: uma análise segundo a regressão de componentes principais** *Alessandra Pasqualina Viola, Margarida Sarmiento Gutierrez, Octávio Bessada Lion e Cláudio Henrique Barbedo*	Nov/2009
199	**Delegated Portfolio Management and Risk Taking Behavior** *José Luiz Barros Fernandes, Juan Ignacio Peña and Benjamin Miranda Tabak*	Dec/2009
200	**Evolution of Bank Efficiency in Brazil: A DEA Approach** *Roberta B. Staub, Geraldo Souza and Benjamin M. Tabak*	Dec/2009
201	**Efeitos da Globalização na Inflação Brasileira** *Rafael Santos e Márcia S. Leon*	Jan/2010
202	**Considerações sobre a Atuação do Banco Central na Crise de 2008** *Mário Mesquita e Mario Torós*	Mar/2010
203	**Hiato do Produto e PIB no Brasil: uma Análise de Dados em Tempo Real** *Rafael Tiecher Cusinato, André Minella e Sabino da Silva Pôrto Júnior*	Abr/2010
204	**Fiscal and monetary policy interaction: a simulation based analysis of a two-country New Keynesian DSGE model with heterogeneous households** *Marcos Valli and Fabia A. de Carvalho*	Apr/2010
205	**Model selection, estimation and forecasting in VAR models with short-run and long-run restrictions** *George Athanasopoulos, Osmani Teixeira de Carvalho Guillén, João Victor Issler and Farshid Vahid*	Apr/2010
206	**Fluctuation Dynamics in US interest rates and the role of monetary policy** *Daniel Oliveira Cajueiro and Benjamin M. Tabak*	Apr/2010
207	**Brazilian Strategy for Managing the Risk of Foreign Exchange Rate Exposure During a Crisis** *Antonio Francisco A. Silva Jr.*	Apr/2010
208	**Correlação de *default*: uma investigação empírica de créditos de varejo no Brasil** *Antonio Carlos Magalhães da Silva, Arnildo da Silva Correa, Jaqueline Terra Moura Marins e Myrian Beatriz Eiras das Neves*	Maio/2010
209	**Produção Industrial no Brasil: uma análise de dados em tempo real** *Rafael Tiecher Cusinato, André Minella e Sabino da Silva Pôrto Júnior*	Maio/2010
210	**Determinants of Bank Efficiency: the case of Brazil** *Patricia Tecles and Benjamin M. Tabak*	Apr/2010