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Revisions in the Norwegian National Accounts

Accuracy, unbiasedness and efficiency in preliminary figures

TALL SOM FORTELLER

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Abstract:

This paper investigates the quality of preliminary figures in the Norwegian national accounts. To address the problem of few observations in such analyses, we use some recently developed system tests. Preliminary figures for gross fixed capital formation (investments) under-predict the final figures. For other series in the Norwegian national accounts, we find that they are unbiased and weakly efficient.

Keywords: Forecasting

JEL classification: C12, C22, C32, E01

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Sammendrag

Endelige tall for årlig nasjonalregnskap (basert på normal revisjonssyklus) publiseres ikke før halvannet år etter utgangen av året de gjelder for. Før de endelige tallene publiseres, er man avhengig av foreløpige tall. De foreløpige tallene er viktige da de utgjør et grunnlag for utformingen av penge- og finanspolitikken. De er også viktige for de sentrale lønnsforhandlingene. Det er derfor viktig at de foreløpige tallene er gode prediktorer på de endelige tallene og så nøyaktige som mulig.

I denne artikkelen sammenligner vi foreløpige tall for vekst i BNP og anvendelseskomponentene for BNP med de tilsvarende endelige nasjonalregnskapstallene. For å vurdere om de foreløpige tallene skal kunne karakteriseres som gode har vi benyttet tre kriterier. For det første om de er forventningsrette, det vil si at de ikke systematisk er høyere eller lavere enn de endelige tallene. For det andre om volatiliteten i revisjonene fra foreløpige til endelige tall er liten og mindre enn variasjonen i de endelige nasjonalregnskapstallene. For det tredje må de foreløpige tallene være effisiente, det vil si reflektere all tilgjengelig informasjon. Det er vanskelig å vurdere om de foreløpige tallene tilfredstiller det siste kriteriet, men en kan teste en svak form for effisiens.

Vi finner at de forløpige nasjonalregnskapstallene stort sett er forventningsrette estimater. Unntaket er bruttoinvesteringer i fast realkapital der man over tid har anslått for lave tall i de foreløpige publiseringene. Vi konkluderer også med at det er forsvarlig små endringer når man går fra foreløpige til endelige tall. Forholdet mellom variansen til revisjonene og variansen til de endelige tallene er klart størst for offentlig konsum.

For å teste om de foreløpige nasjonalregnskapstallene er svakt effisiente har vi benyttet to ulike tester. I den ene testen ser vi på om de foreløpige vekstanslagene systematisk over- eller undervurderer veksten i de endelige nasjonalregnskapstallene (slik at man kan få et bedre anslag på de endelige tallene ved enten å justere opp eller ned de forløpige tallene, samt nivåjustere vekstraten). En slik skjevhet finner vi ikke støtte for. I den andre testen ser vi om en nyere versjon av foreløpige tall inkluderer all informasjon som en tidligere publisering av de samme nasjonalregskapstallene inneholder (slik at man ikke kan få et bedre anslag på endelige tall ved å benytte tidligere publiserte foreløpige tall i tillegg til de sist publiserte nasjonalregnskapstallene). Med unntak for bruttoinvesteringer i fast realkapital finner vi støtte for svak effisiens.
[Klikk for å sette inn tekst]

1 Introduction

Final vintage of annual national accounts figures (based on the normal revision cycle) are published approximately one year and a half after the end of the year for which they apply. Before the final figures are released, preliminary figures are used, among other things, in policy formulation. Therefore, it is important that the preliminary figures are good predictors of the final figures and as accurate as possible.

Data revisions and their implications have been studied on many years. Cole (1969) found that for certain types of forecasts, ”The use of preliminary rather than revised data resulted in a *doubling* of the forecast error”. Investigating preliminary national accounts figures for Germany, Strohsal and Wolf (2020) conclude that the revisions are ”biased, large and predictable”, with the noteworthy exception for GDP. Similar results were found for the US in Aruoba (2008). A recent special issue of *Empirical Economics*, see Kunst and Wagner (2020), focuses on forecasting of macroeconomic variables and on the consequence of final vintage of national account figures not being available when forecasts (or nowcasts) are made. For example, Siliverstovs (2020) considers the problem of nowcasting (both point forecasting and density forecasts) when conditioning on variables that are preliminary, and finds that a simple univariate model can be better than a sophisticated mixed frequency model to obtain good nowcasts. On the other hand, Claudio et al. (2020) find that a mixed frequency model outperforms forecasts obtained by more traditional single-frequency models when applying data available in real-time. Glocker and Wegmueller (2020) considers the problem of dating recessions when taking revisions of GDP into account.

There are only a few previous studies of revisions of the Norwegian National Accounts. Bernhardsen et al. (2005) consider the problem of estimating the output gap based on preliminary national accounts figures in Norway. They ”find that total revisions of output gap estimates are heavily influenced by uncertainty about the trend at the end of the sample and that data revisions are of less importance”. Jore (2017), studying quarterly Norwegian national accounts data, finds that first releases of growth in both nominal GDP and its deflator under-predicts the final figures. However, these biases cancel out such that ”there is no tendency for the first released data [for real growth in GDP] to either over- or under-predict the final data.” Although these two papers analyse revisions in GDP for Norway, they do not study the revisions for all of the main aggregates in the National Accounts.

In this paper, we compare the preliminary published figures of GDP and its main components to the final published figures of these variables.

For the preliminary figures to be characterized as good, they must satisfy certain requirements (see also Aruoba, 2008). First, they must be unbiased estimates of the final figures, which we find in tests for most of the figures, both separately and jointly. Second, they must have a small variance (compared to the variance of the final vintage of the figures), and its variance must decrease with new vintages. For most of the national account figures, we find support for both a small and a decreasing variance with newer vintages. Third, they must be efficient; that is, they utilize all available information at the time they are published. In practice, it is impossible to test that there does not exist any available information at the time the preliminary national accounts figures were made that could have improved them. However, it is possible to test if one can improve the preliminary figures by using its unconditional mean or earlier vintages of the same variables (also known as weakly efficiency). We test weakly efficiency both with a test based on Mincer and Zarnowitz (1969) and with an encompassing test. The efficiency test based on Mincer and Zarnowitz (1969) indicates that the preliminary national accounts figures cannot be improved by replacing them with a weighted average of the preliminary figures and an unconditional expectation estimate. We show that this test also implies that more "news" is incorporated into the preliminary figures through the review process. The results from the encompassing tests support this conclusion; new preliminary vintages of the national accounts figures seem generally contain all information from earlier vintages, so the latest vintages cannot be improved using earlier vintages.

When testing for efficiency, we do not only apply tests on the national accounting variables separately. We also apply tests of efficiency for the whole vector of variables. The test we use for this is proposed in Hungnes (2018). One of the advantages of testing all of the elements in this vector jointly, is that the test can have better power than tests for each variable separately has. (Also, it may be easier to draw conclusions from such a joint test if you get divergent results for different variables when testing these separately.)

The tests for efficiency might have weak power in small data sets, even if tested jointly. We therefore also apply equal predictability tests, where we examine whether two vintages of the preliminary national accounts figures are equally good predictors of the final ones. We usually fail to reject this hypothesis when we test the variables separately (with some exceptions). However, when we use the test in Hungnes (2019) to test this hypothesis for all variables jointly, we reject the hypothesis that two vintages of the national accounts figures are equally good predictors for the final ones. Furthermore, the estimates in the tests show that this rejection occurs because the vector of the most recent vintage of preliminary national accounts figures is significantly better than the vector of an earlier vintage of the same figures.

Although the tests generally show that the preliminary national accounts figures are unbiased and weakly efficient, there are some exceptions. In particular, this applies to the gross fixed capital formation (a component of gross capital formation). For this variable, it turns out that the preliminary figures are significantly too small for all vintages and that this bias is increasing through the revision process.

Thus, the projections of this variable get worse the closer you get to the time of final vintage of national accounts figures are published. The preliminary vintages of the national accounts figures would have been better if you had kept the figures published in the first vintage of this variable until the final figure is published.

The present paper takes benchmark revisions directly into account. In the main analysis, we do so by attributing the change in the growth rates from the last publication before the benchmark revision to the first publications directly after the benchmark revision to be treated as the effect of the benchmark revision.

The paper is organized as follows: Section 2 describes the revision cycle in the Norwegian national account and gives an overview of the different sources used for the various vintages throughout the revision cycle. The section also gives an overview of the various benchmark revisions that have taken place in the period we are considering and presents the national account variables we are considering in this study. Section 3 describes the accuracy for the preliminary vintages the variables considered, tests for unbiasedness in preliminary vintages, as well as considers two efficiency tests (including an encompassing test) and an equal predictability test. Section 4 concludes.

2 Revision cycles, sources, and the national account data

The national accounts publish annual figures in a relatively fixed cycle: The first to third vintages of the annual figures are preliminary estimates based on the system of the Quarterly National Accounts (QNR). The fourth vintage is the final in the regular revision cycle and is based on the system of the annual National Accounts (NA). The first vintage of the annual figures is published when all the quarters of the year they apply for are available. Since the NA figures of 2006, the first vintage has been published at the beginning of February (about 40 days after the end of the year they apply for). The second vintage (for the year 2006 and later) has been published in May (about 19 weeks after the end of the year they apply to); and the third vintage (for the year 2014 and later) has been published in August (about 34 weeks after the end of the year they apply for). The fourth vintage, which is the final vintage in the regular revision cycle, has (for the year of 2013 and later) been published in August one year after the third vintage (about 20 months after the end of the year they apply to). As a result of benchmark revisions, figures can be revised also after the publication of the fourth vintage.

The times for publishing the different preliminary vintages have changed somewhat over time. For the NA figures for the years 2003-2017, the changes have been exclusively in the direction of higher timeliness. Table 1 shows an overview of the revision cycle for GDP for the mainland Norwegian economy (Mainland GDP). The table also indicates by means of color codes which benchmark revision each figure was published under.

Benchmark revisions usually implies changes in the national accounts' definitions and guiding principles. If the first vintage of the NA figures for a year were published before a benchmark revision, while the final vintage was published after or as part of a benchmark revision, then revisions from preliminary to final figures could come from definitions and guidance changes, in addition to normal revisions within the regular publishing cycle.

The publication dates were accelerated (moved forward) one month from 2007, which included starting with the fourth vintage of the NA figures for 2005 and the three first vintages of the NA figures for 2006. Final NA figures for 2008 were published one year later than what the regular revision cycle implies, due to challenges with the transition to a new business classification (SN2007), such that they were published in connection with the benchmark revision of 2011. As of 2015, the third and fourth vintage were accelerated (moved forward) one quarter, which included starting with the fourth vintage of the NA figures for the year of 2013 and third vintage of the NA figures for the year of 2014.

2.1 Sources in the revision cycle

When the first vintage is published, most of the short-term statistics are included in the QNA system. This publication is based on monthly and quarterly figures from the state accounts and KOSTRA (Municipality-State-Reporting), respectively, as the basis for developments in public administration. Several units, including state education and health, have no reporting obligation other than annual figures, so these are estimated in all quarters for the first vintage. For foreign trade, goods data are available, while import and export of services are estimated at a smaller subset for the fourth quarter of the year.

For the second vintage, updated figures for public management are available as annual figures from both the state accounts and KOSTRA are now available. For the state accounts, this implies a full census, while for KOSTRA the reporting deadline for the annual figures is somewhat longer so that several units are missing. For foreign trade, there are some revisions in the goods data, but the main source of revision is that there are complete fourth-quarter figures for service trade. Otherwise, revisions in the short-term statistics can lead to revisions in the NA figures.

The third vintage has full KOSTRA figures, which can give revisions in municipal administration. Also, preliminary structural statistics are available, which will improve the market-oriented industries. In connection with the publication of the third vintage, the base year in the QNA is also updated. The shift of base year implies that the short-term indicators in the QNA are weighted together with the NA figures from a more recent year. Changing the base year can provide revisions in itself, even though we

Table 1: Revisions for annual growth in GDP Mainland Norway, 1988-2017

year	Vintage 1	Vintage 2	Vintage 3	Vintage 4	Revision
1988	0.4	-0.1	-1.0	-1.7	
1989	-0.9	-1.2	-2.5	-2.2	BR1972
1990	1.2	0.7	1.1	1.1	
1991	0.2	-0.3	-0.6	1.1	
1992	1.3	2.0	2.1	2.2	
1993	2.2	1.9	1.7	2.8	
1994	3.9	4.8	4.3	4.1	
1995	3.3	2.7	3.1	2.9	BR1995
1996	3.2	3.7	4.1	3.8	
1997	3.9	3.8	4.4	4.2	
1998	2.9	3.3	3.3	3.6	
1999	0.8	0.8	1.0	2.7	
2000	1.8	1.8	1.9	2.5	
2001	1.0	1.2	1.7	2.1	BR2002
2002	1.3	1.3	1.7	1.4	
2003	0.7	0.6	0.7	1.4	
2004	3.5	3.5	3.4	4.4	
2005	3.7	3.7	4.1	4.6	
2006	4.6	4.6	4.3	4.9	BR2006
2007	6.0	6.2	6.1	5.6	
2008	2.4	2.6	2.2	1.5	
2009	-1.5	-1.6	-1.3	-1.6	
2010	2.2	2.1	1.9	1.7	BR2011
2011	2.6	2.4	2.5	2.6	
2012	3.5	3.4	3.4	3.8	
2013	2.0	2.0	2.3	2.3	
2014	2.3	2.2	2.2	2.2	BR2014
2015	1.0	1.0	1.1	1.4	
2016	0.8	0.9	1.0	1.1	
2017	1.8	1.9	2.0	2.0	BR2019

have no new information in the short-term statistics.

For the fourth and final vintage, the figures are based on the NA system. The NA system utilizes more sources than the QNA system, and the calculations are done on a more detailed level. In addition, the volume calculations in QNA are mainly done by extrapolating the NA sizes with suitable volume indicators. The NA system consists of accounting sizes at current prices, which are then deflated by suitable price indices to give rise to volume growth.

2.2 Benchmark revisions

At more or less regular intervals - approximately every five years - revisions of the NA series of figures are carried out in the national accounts. These are referred to as benchmark revisions, and normally include the incorporation of new definitions and classifications that come with international regulations. Benchmark revisions may also include the incorporation of new source material, new calculation schemes, and any error correction without any definition changes being made. Benchmark revisions often lead to level shifts in the time series. In connection with the publication of benchmark revisions, the time series in the national accounts are updated. This is done to ensure that the time series are consistent and comparable back in time to provide the most accurate picture of developments. For the years 1988-2017, there have been three six benchmark revisions (BR): BR1995, BR2002, BR2006, BR2011, BR2014, and BR2019.[1]

BR1995 involved the incorporation of new definitions and guidelines from SNA93, as well as the review and inclusion of new statistical data from the last 10-15 years before the benchmark revision started. Due to the extensive work for preparing the benchmark revision, the final vintage for the years 1991 was delayed and finally published according to BR1995.

BR2002 was a comprehensive revision without new definitions and classifications. The main reason for carrying out the numerical revision was that Statistics Norway compiled new structural statistics for several industries during the 1990s, and the new statistic sources showed a much higher level of central variables than previous statistics. The results of the revision were published in June 2002, with revised final figures for 1991-1999, as well as new preliminary figures for 2000 and 2001.

BR2006 was published in December 2006. The main reason for the revision was an EU regulation that required the size of indirectly measured banking and financial services to be distributed to end-users — such as product intervention or consumption — rather than being deducted from gross domestic product in a correction item. This revision resulted in a higher level of GDP.

[1] Eurostat has adopted a harmonised revision policy for national accounts, which foresees a combination of routine revisions, benchmark revisions and non-scheduled revisions when necessary (Eurostat, 2019). The policy aims at coordinating benchmark revisions across the national statistical institutes. The next benchmark revision is planned for dissemination in 2024. Statistics Norway follows these guidelines.

Table 2: GDP and its main components, 2017

Variable name	billion NOK	share of GDP
Gross domestic product (GDP)	3 295.4	100.00
—— Gross domestic product Mainland Norway (GDPM)	2 792.0	84.73
— Final consumption expenditure of household and NPISHs (CP)	1 471.7	44.66
— Final consumption expenditure of general government (CO)	791.1	24.01
— Gross capital formation (J)	917.2	27.83
—— Gross fixed capital formation (JK)	809.4	24.57
— Total exports (EX)	1 197.3	36.33
— Total imports (IMP)	-1 081.9	-32.83

NPISHs: Non-profit institutions serving households

BR2011 was published in November 2011. The most significant change was the incorporation of a new industry standard, SN2007. The new industry standard was the reason why the final vintage for the year of 2008 was delayed by one year.

BR2014 was published in November 2014. The most significant change that this major revision entailed was that research and development work went from being treated as ongoing product efforts to being treated as investments. Therefore, the benchmark revision redistributed costs from product efforts to investments, and the result was a higher level of GDP. The definition of Mainland Norway was also changed, and contributed to an increased growth in Mainland GDP (see also footnote 2 below).

BR2019 was published in August 2019, and incorporation of a new data source for salaries and employment (”a-ordningen”) was the most important single cause of the revisions. Transfer of some specific units from market producers to government sector, as well as a change in how some existing sources are used, have caused other corrections.

2.3 National account series considered here

In the current paper, we consider gross domestic product (GDP) and its main component, see Table 2. These are *final consumption expenditure of household and non-profit institutions serving households* (CP), which in 2017 make up about 45 percent of GDP; *final consumption expenditure of general government* (CO), which make up about 24 percent of GDP; *gross capital formation* (J), representing about 28 percent of GDP; *total exports* (EXP), representing about 36 percent of GDP; and *total imports*, corresponds to about 33 percent of GDP.

Gross capital formation includes *changes in stocks and statistical discrepancies*. Since it includes statistical discrepancies, the figure is derived from the sum of GDP and import minus final consumption expenditure (CP+CO+EXP) and changes in the figure for *gross capital formation* between vintages may not reflect new information on *gross capital formation*. Therefore, we also consider *gross fixed capital formation* (JK), which constitutes the most of *gross capital formation*, as unique information is used to make these national account figures.

In Norway, GDP Mainland is considered as the most important national account figure. GDP Mainland is defined as the total GDP minus *Petroleum activities and ocean transport*.[2] In 2017, GDP for Mainland Norway constituted about 85 percent of total GDP.

The vintages of Mainland GDP for all the ficsal years 1988–2017 are reported in Table 1.[3]

3 Tests of unbiasedness and efficiency

Let $y^i_{t,(j)}$ be the j'th vintage of the NA figure of variable i applying for year t, where $i = 1, 2, \ldots, K$ with K as the number of national account variables we are considering. The 4'th vintage of this figure is treated as the final value. Thus, the prediction error for the j'th vintage of variable i for year t is defined as $e^i_{t,(j)} = y^i_{t,(4)} - y^i_{t,(j)}$ $(j = 1, 2, 3)$. The variables are measured in percent growth from the previous year with one decimal as in Table 1.

Due to benchmark revisions, for many years, we have that the first vintage of the National Accounts figures is based on one benchmark revision standard, while the final version is based on another benchmark revision standard. We consider here three different approaches to handling this.

In the first approach, we ignore that such revisions have taken place. Although benchmark revisions may change the level of the variable, it will not necessarily change the year-to-year growth of the variable, since the level of the variable for the previous year is also changed. As the first year with national account figures for GDP Mainland Norway was in 1988, and the last year with final national account figures are from 2017, we consider all years from 1988 to 2017 — giving us a sample of 30 observations.

In the second approach, we exclude the years where such benchmark revisions have taken place between the first and the last vintage. As there are 15 years where there has been a benchmark revision between the publication of the first and the final NA figures, we only have a sample of 15 years where there have not been such revisions during the publication process.

In the third approach, we adjust for the effect of the benchmark revisions have on the figures. If a revision has taken place between vintage j and vintage $j+1$ of variable i applying for year t (and we expect that when adjusting for this revision the vintage j should be an unbiased predictor of vintage $j+1$ of the same variable for the same year), the best adjustment for the benchmark revision is the change in the preliminary figure of this variable for year t from vintage j to vintage $j+1$. Let $R_{t,(j)}$ be an indicator variable, taking the value of 1 if there is an benchmark revision between version j and $j+1$

[2]Before 2014, *service activities incidental to oil and gas* were also excluded from the definition of Mainland GDP.

[3]The data considered here are downloadable from https://www.ssb.no/nasjonalregnskap-og-konjunkturer/artikler-og-publikasjoner/_attachment/382739?_ts=169d809c9d0 with the exception for the final vintage for the year of 2017. These are 2.3 for GDP, 2.0 for GDPM (as also reported in Table 1), 2.2 for CP, 1.9 for CO, 3.1 for J, 2.6 for JK, 1.7 for EX, and 1.9 for IMP.

for year t, and zero otherwise. Then the adjusted predictions are given by

$$y^{i,*}_{t,(j)} = y^i_{t,(j)} + \sum_{k=j}^{3} \left(y^i_{t,(k+1)} - y^i_{t,(k)} \right) R_{t,(k)}, \tag{1}$$

such that the adjusted prediction errors are given by[4]

$$e^{i,*}_{t,(j)} = e^i_{t,(j)} + \sum_{k=j}^{3} \left(y^i_{t,(k+1)} - y^i_{t,(k)} \right) R_{t,(k)}. \tag{2}$$

For example, consider the GDP growth for 1991 from vintage 3 (se Table 1), which is -0.6, ie $y^{GDP}_{1991,(3)} = -0.6$. Before the final figure is published there is a benchmark revision, so we have $R_{1991,(3)} = 1$. Applying (1), we have $y^{GDP*}_{1991,(3)} = \mathrm{y}^{GDP}_{1991,(3)} + (\mathrm{y}^{GDP}_{1991,(4)} - \mathrm{y}^{GDP}_{1991,(3)}) = \mathrm{y}^{GDP}_{1991,(4)} = 1.1$, implying that we are revising the GDP growth for vintage 3 up by 1.7 percentage points. The GDP growth for 1991 in vintage 1 and 2 are revised up by the same figure of percentage points, as this is our estimate of the effect of the benchmark revision for GDP in 1991. Furthermore, applying (2), we have $e^{GDP*}_{1991,(3)} = 0$. Thus, if the benchmark revision takes place between the 3rd and the final (4th) vintage, we are essentially comparing the preliminary figures with its 3rd vintage.

The first approach, where we ignore that a benchmark revision has taken place between the first and final vintage (for the normal revision cycle), seems to be the usual approach in such analysis (especially when the variables are formulated in percentage growth); see, e.g., Strohsal and Wolf (2020) and Aruoba (2008). Our third approach, where we adjust for benchmark revisions, is more in line with Clements and Galvão (2013), who include "benchmark dummies" to adjust for benchmark revisions.

3.1 Accuracy

The root mean squared error (RMSE) for vintage j of variable i is given by

$$RMSE^i_{(j)} = \sqrt{\frac{1}{N} \sum_{t \in \mathcal{T}} \left(e^i_{t,(j)} \right)^2}, \tag{3}$$

where $\mathcal{T}$ contains the years included in the sample, and N is the number of elements in $\mathcal{T}$. If we include all years we have $N = 30$. If we only include years for which there has been no benchmark revision we have $N = 15$. And if we adjust for benchmark revisions by using (2), we have $N = 30$ for vintage 1 and 2

[4]This can also be formulated as

$$\begin{aligned}
e^{i,*}_{t,(3)} &= \left(1 - R_{t,(3)}\right) e^i_{t,(3)} \\
e^{i,*}_{t,(2)} &= e^{i,*}_{t,(3)} + \left(1 - R_{t,(2)}\right) \left(e^i_{t,(2)} - e^i_{t,(3)}\right) \\
e^{i,*}_{t,(1)} &= e^{i,*}_{t,(2)} + \left(1 - R_{t,(1)}\right) \left(e^i_{t,(1)} - e^i_{t,(2)}\right)
\end{aligned}$$

and $N = 22$ for vintage 3.[5] In our analysis, we have $t_1 = 1988$ as the first year we are considering (since this is the first year with national account figures for GDP for the Norwegian mainland economy) and $T = 2017$ (since this is the last year with final national accounts figures). When we adjust for benchmark revisions, we replace $e^i_{t,(j)}$ with $e^{i,*}_{t,(j)}$ in (3).

The RMSE can be seen as a measure of the accuracy of the preliminary figures. It is reported in Table 3 for the adjusted prediction errors (see also Table A1 and Table A6 in Appendix A for the results obtained under alternative treatments of benchmark revisions). The average bias in the preliminary figures is $\bar{e}^i_{(j)} = N^{-1} \sum_{t\in\mathcal{T}} e^i_{t,(j)}$. The RMSE can then be decomposed into a prediction variance and a bias component:

$$RMSE^i_{(j)} = \sqrt{PV^i_{(j)} + \left(\bar{e}^i_{(j)}\right)^2} \text{ where } PV^i_{(j)} = \frac{1}{N}\sum_{t\in\mathcal{T}} \left(e^i_{t,(j)} - \bar{e}^i_{(j)}\right)^2$$

The square root of the prediction variance is also reported in Table 3 (whereas the bias component will be considered in the next section). For comparison, Table 3 also reports the root of the variance of the final vintage of the variable, see the final column of the table, where the variance is given as

$$V^i = \frac{1}{N}\sum_{t\in\mathcal{T}} \left(y^i_{t,(4)} - \bar{y}^i_{(4)}\right)^2.$$

This measure can be used as a benchmark for the prediction variance of the preliminary figures. If the preliminary figure for a variable were the same each year (that is, if $y^i_{1988,(j)} = y^i_{1989,(j)} = \cdots = y^i_{2017,(j)}$), then the prediction variance of this vintage f the variable would be equal to the variance of the final vintage. Therefore, V^i could be considered as an upper limit for the prediction variance.

From Table 3 (and also Table A1 and Table A6) we draw the following conclusions:

First, the preliminary figures for private consumption expenditure of households and non-profit institutions serving households (CP) are the most accurate of the national account figures we are considering, based on both RMSE and the root of the prediction variance. However, for the third vintage, the preliminary figures for GDP and Mainland GDP (GDPM) are approximately equally accurate as CP.

Second, the preliminary figures for gross capital formation (J) and its main component gross fixed capital formations (JK) are the least accurate national account figures we are considering here. For the first two vintages these figures have an RMSE about four times as high as those for CP, GDP, and GDPM. However, this is due to the high volatility in investments over time. The root of the variance of the final vintage figures for these two investment types are also about four times as high as those for CP, GDP,

[5] When we adjust for benchmark revisions we have for vintage 3 essentially $30 - 8 = 22$ observations as the correction conducted in (2) implies that the adjusted prediction error of the preliminary figure of the 3rd vintage of the figure will be zero in all of the 8 years in the sample where there was a benchmark revision between vintage 3 and the final vintage.

Table 3: Accuracy in preliminary figures, 1988-2017 (adjusted preliminary figures)

Variable	Vintage 1 ($N = 30$) $RMSE^i_{(1)}$	$\sqrt{PV^i_{(1)}}$	$\sqrt{\frac{PV^i_{(1)}}{V^i}}$	Vintage 2 ($N = 30$) $RMSE^i_{(2)}$	$\sqrt{PV^i_{(2)}}$	$\sqrt{\frac{PV^i_{(2)}}{V^i}}$	Vintage 3 ($N = 22$) $RMSE^i_{(3)}$	$\sqrt{PV^i_{(3)}}$	$\sqrt{\frac{PV^i_{(3)}}{V^i}}$	Final vintage ($N = 30$) $\sqrt{V^i}$
GDP	0.67	0.67	0.44	0.57	0.57	0.36	0.42	0.40	0.29	1.46
GDPM	0.64	0.64	0.39	0.55	0.54	0.30	0.44	0.42	0.23	1.91
CP	0.58	0.58	0.34	0.53	0.53	0.29	0.41	0.41	0.23	1.81
CO	0.93	0.91	0.65	0.88	0.88	0.58	0.88	0.88	0.66	1.32
J	2.53	2.50	0.32	2.10	2.10	0.26	1.88	1.86	0.23	8.13
JK	2.29	2.19	0.26	2.43	2.25	0.29	2.65	2.41	0.34	7.82
EX	1.16	1.11	0.31	0.82	0.81	0.23	0.97	0.93	0.26	3.71
IMP	1.55	1.49	0.33	1.00	1.00	0.21	0.79	0.76	0.17	4.62

Root mean squared error (RMSE) and root of both the absolute and the relative prediction variance, as well as the root of the variance of the final vintage.

and GDPM.

Third, for most variables, the accuracy increases for later vintages. Recall that the figure of observations is $N = 22$ in vintage 3, implying that vintage 2 and vintage 3 are not directly comparable; for CO the RMSE (and also the root of FV) is equal for vintages 2 and 3. However, this seems to be due to the changed figure of observations, as RMSE decreases both when we consider the full sample (see Table A1) and only years for which there are no benchmark revisions (see Table A6). For JK the accuracy decreases throughout the revision cycle, as RMSE (and FV) increases with the vintage figure for these variables. For export (EX), however, the third vintage seems to be less accurate than the second vintage, independent of how benchmark revisions are treated.

Fourth, based on the ratio between prediction variance and the variance of the final vintage (also known as the noise-to-signal ratio, see, e.g., Aruoba, 2008), CO has the least accurate figure for all vintages.

Fifth, RMSE for the adjusted prediction errors given by (2) reported in Table 3 are smaller than the corresponding RMSE for the unadjusted prediction errors for the full sample reported in Table A1. This indicates that the correction for benchmark revisions in (2) works well.

Sixth, the small difference between RMSE and the root of prediction variance, indicating only small biases. The biggest difference is found for JK. Below, we will formally test for the absence of bias.

3.2 Unbiasedness

The test of unbiasedness is based on the regression

$$e^i_{t,(j)} = \mu^i_{(j)} + u^i_{t,(j)}, \tag{4}$$

where $u^i_{t,(j)}$ is a mean-zero error term, and $\hat{\mu}^i_{(j)} = \bar{e}^i_{(j)}$. Let $d^i_t = e^i_{t,(j)}$ and $\bar{d}^i = N^{-1}\sum_{t\in\mathcal{T}} d^i_t = \bar{e}^i$ (where we suppress the subscript j for vintage). A t-test statistic for the null hypothesis $\mu^i_{(j)} = 0$ is

$$N^{1/2}\bar{d}^i\left(\hat{q}^i\right)^{-1/2} \tag{5}$$

where $\hat{q}^i$ is a consistent estimate of the variance of d^i_t. We use

$$\hat{q}^i = \frac{1}{N}\sum_{t\in\mathcal{T}}\left(d^i_t - \bar{d}^i\right)^2 + \frac{2}{N}\sum_{l=1}^{\tau}\sum_{t,t+l\in\mathcal{T}} w_l\left(d^i_t - \bar{d}^i\right)\left(d^i_{t+l} - \bar{d}^i\right), \tag{6}$$

where τ is the order of autocorrelation (where we in the current paper assume $\tau = 1$ due to few observations), and w_l denotes weights (where we follow Newey and West (1987) and use $w_l = 1 - \frac{l}{\tau+1}$). Furthermore, the notation $t, t+l \in \mathcal{T}$ means that we take the sum over all combinations where both t and $t+l$ are elements in $\mathcal{T}$. The test statistic given by (5) is asymptotically normally distributed. However, in small samples we assume it to be t-distributed with $N-1$ degrees of freedom.

We also consider the joint test of all elements in the vector $\left(\mu^1_{(j)}, \mu^2_{(j)}, \ldots, \mu^K_{(j)}\right)'$ being zero, by applying the test statistic

$$N\bar{\mathbf{d}}'\hat{\mathbf{Q}}^{-1}\bar{\mathbf{d}}, \tag{7}$$

with $\bar{\mathbf{d}} = \left(\bar{d}^1, \bar{d}^2, \ldots, \bar{d}^K\right)'$, and $\hat{\mathbf{Q}}$ being a matrix version of $\hat{q}$ defined as

$$\begin{aligned}\hat{\mathbf{Q}} =& \frac{1}{N}\sum_{t\in\mathcal{T}}\left(\mathbf{d}_t - \bar{\mathbf{d}}\right)\left(\mathbf{d}_t - \bar{\mathbf{d}}\right)' \\ &+ \frac{1}{N}\sum_{l=1}^{\tau}\sum_{t,t+l\in\mathcal{T}} w_l\left(\mathbf{d}_t - \bar{\mathbf{d}}\right)\left(\mathbf{d}_{t+l} - \bar{\mathbf{d}}\right)' \\ &+ \frac{1}{N}\sum_{l=1}^{\tau}\sum_{t,t+l\in\mathcal{T}} w_l\left(\mathbf{d}_{t+l} - \bar{\mathbf{d}}\right)\left(\mathbf{d}_t - \bar{\mathbf{d}}\right)',\end{aligned} \tag{8}$$

with $\mathbf{d}_t = \left(d^1_t, d^2_t, \ldots, d^K_t\right)'$. The test statistic in (7) is asymptotically χ^2-distributed with K degrees of freedom. In small samples, however, we assume it to be F-distributed with K degrees of freedom in the nominator and $N-1$ degrees of freedom in the denominator.[6]

Table 4 reports the test results for unbiasedness (see also Table A2 and Table A7): Using a 5 percent significance level, we reject the null hypothesis that the preliminary data are unbiased, except for the second vintage of JK. This is also (more or less) confirmed in Table A7, whereas in Table A2 we can not

[6] A potential problem with this and the remaining joint test is the approximately linear relationship between the variables measured in percent growth: $\frac{GDP_t}{GDP_{t-1}} = s_{CP,t-1}\frac{CP_t}{CP_{t-1}} + s_{CO,t-1}\frac{CO_t}{CO_{t-1}} + s_{J,t-1}\frac{J_t}{J_{t-1}} + s_{EXP,t-1}\frac{EXP_t}{EXP_{t-1}} - s_{IMP,t-1}\frac{IM_t}{IMP_{t-1}}$, where $s_{CP,t} = \frac{CP_t}{GDP_t}$ is the private consumption to GDP ratio in year t (and similarly for $s_{CO,t}$, $s_{J,t}$, $s_{EXP,t}$, and $s_{IMP,t}$). If these ratios are time-invariant, the covariance matrix in 8 (and also $\tilde{\Omega}$ for the later defined *t-test*) will not be positive definite and, thus, not invertible. If this is a problem, one can exclude one of the variables.

Table 4: Tests for absence of bias in preliminary figures, 1988-2017 (adjusted preliminary figures)

	Vintage 1 ($N = 30$)				Vintage 2 ($N = 30$)				Vintage 3 ($N = 22$)			
Variable	$\hat{\mu}$	std. err.	test st.	p-val.	$\hat{\mu}$	std. err.	test st.	p-val.	$\hat{\mu}$	std. err.	test st.	p-val.
GDP	0.00	0.15	0.02	0.98	0.02	0.11	0.21	0.84	0.13	0.08	1.60	0.12
GDPM	0.03	0.13	0.25	0.80	0.08	0.10	0.74	0.47	0.11	0.08	1.30	0.21
CP	0.02	0.11	0.15	0.88	0.02	0.10	0.19	0.85	0.03	0.09	0.34	0.74
CO	0.21	0.15	1.38	0.18	0.07	0.18	0.41	0.68	0.03	0.21	0.15	0.88
J	-0.34	0.50	-0.67	0.51	-0.19	0.37	-0.50	0.62	-0.28	0.40	-0.70	0.49
JK	0.69	0.35	1.95	0.06	0.91	0.40	2.29	0.03*	1.10	0.54	2.06	0.05
EX	0.33	0.22	1.50	0.14	0.10	0.15	0.66	0.52	0.27	0.21	1.29	0.21
IMP	0.44	0.29	1.54	0.13	-0.06	0.18	-0.32	0.75	-0.24	0.17	-1.42	0.17
All	..	..	2.25	0.05	..	..	2.59	0.03*	..	..	3.04	0.02*
All exc. JK	..	..	0.87	0.54	..	..	0.93	0.50	..	..	2.09	0.09

Testing the null hypothesis of $\mu^i_{(j)} = 0$ in the regression $e^{i*}_{t,(j)} = \mu^i_{(j)} + u^i_{t,(j)}$, where $e^{i*}_{t,(j)}$ is the adjusted difference between vintage j and the final vintage of a national account figure or vector of those figures. All tests where standard error (std. err.) is reported are t-tests with $N-1$ degrees of freedom when one variable is tested and $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested; otherwise the tests are F-tests with K degrees of freedom in the nominator and $N-1$ degrees of freedom in the denominator.

reject the null hypothesis for JK. Since we are using a 5 percent significance level for the tests, we will expect 1 out of 20 independent tests to yield rejection even if the null hypothesis is true. Therefore, based on the tests for each combination of variables and vintages, we could argue that the overall conclusion from the test results reported in Table 4 is that they are in line with the hypothesis that the preliminary figures are unbiased. However, the joint test for unbiasedness, which considers the hypothesis that all preliminary figures are unbiased, is rejected for both vintages 2 and 3. Also, vintage 1 is close to be rejected at the 5 percent significance level, which is due to the biased preliminary figures for JK; if we exclude JK in the vector of considered variables, we cannot reject that the vector of preliminary variables is unbiased. Then our overall conclusion is that preliminary figures for JK is significantly biased and under-predicts the final vintage.

3.3 Weak efficiency

A problem with the test of unbiasedness in the previous section is that we fail to reject the null of absence of bias not only if the estimated bias ($\hat{\mu}^i_{(j)}$) is close to zero but also if the variance in (6) is large. When $\tau = 0$ the latter variance is equal to the prediction variance, and can be decomposed as

$$\begin{aligned}\frac{1}{N}\sum_{t\in\mathcal{T}}\left(e^i_{t,(j)} - \bar{e}^i_{(j)}\right)^2 =& \frac{1}{N}\sum_{t\in\mathcal{T}}\left(y^i_{t,(4)} - \bar{y}^i_{(4)}\right)^2 + \frac{1}{N}\sum_{t\in\mathcal{T}}\left(y^i_{t,(j)} - \bar{y}^i_{(j)}\right)^2 \\ &- 2\frac{1}{N}\sum_{t\in\mathcal{T}}\left(y^i_{t,(4)} - \bar{y}^i_{(4)}\right)\left(y^i_{t,(j)} - \bar{y}^i_{(j)}\right), \end{aligned} \tag{9}$$

(where $\bar{y}^i_{(j)} = N^{-1}\sum_{t\in\mathcal{T}} y^i_{t,(j)}$ ($j = 1, 2, 3, 4$), and, then by definition, $\bar{e}^i_{(j)} = \bar{y}^i_{(4)} - \bar{y}^i_{(j)}$) which shows that this variance does not only become high if there is a high observed variance in the variable we want to predict (the first term), but also if there is a large observed variance in the prediction (the second term), and in particular if the preliminary predictions are not highly positively correlated with the variable we want to predict (the third term).

To handle the problem that non-rejection of unbiasedness can be due to a large variance in (6), we also apply the Mincer and Zarnowitz (1969) regression, which usually is used to test the joint hypothesis of unbiasedness and weak efficiency, given as $\beta_0^i = 0$ and $\beta_1^i = 1$ in

$$\begin{aligned} y_{t,(4)}^i =& \beta_0^i + \beta_1^i y_{t,(j)}^i + v_{t,(j)}^i \\ & \Updownarrow \\ e_{t,(j)}^i - \bar{e}_{(j)}^i =& \beta_1^{i*}\left(y_{t,(j)}^i - \bar{y}_{(j)}^i\right) + v_{t,(j)}^{*i}, \end{aligned}$$

where $\beta_1^{i*} = \beta_1^i - 1$ and $v_{t,(j)}^{*i} = v_{t,(j)}^i - N^{-1}\sum_{s\in\mathcal{T}} v_{s,(j)}^i$. The OLS-estimator for β_1^{i*} is

$$\hat{\beta}_1^{i*} = \frac{\frac{1}{N}\sum_{t\in\mathcal{T}}\left(e_{t,(j)}^i - \bar{e}_{(j)}^i\right)\left(y_{t,(j)}^i - \bar{y}_{(j)}^i\right)}{\frac{1}{N}\sum_{t\in\mathcal{T}}\left(y_{t,(j)}^i - \bar{y}_{(j)}^i\right)^2} = \frac{\frac{1}{N}\sum_{t\in\mathcal{T}}\left(y_{t,(4)}^i - \bar{y}_{(4)}^i\right)\left(y_{t,(j)}^i - \bar{y}_{(j)}^i\right)}{\frac{1}{N}\sum_{t\in\mathcal{T}}\left(y_{t,(j)}^i - \bar{y}_{(j)}^i\right)^2} - 1.$$

Utilizing the expression for $\hat{\beta}_1^{i*}$ in (9) yields

$$\frac{1}{N}\sum_{t\in\mathcal{T}}\left(e_{t,(j)}^i - \bar{e}_{(j)}^i\right)^2 = \frac{1}{N}\sum_{t\in\mathcal{T}}\left(y_{t,(4)}^i - \bar{y}_{(4)}^i\right)^2 - \left(1 + 2\hat{\beta}_1^{i*}\right)\frac{1}{N}\sum_{t\in\mathcal{T}}\left(y_{t,(j)}^i - \bar{y}_{(j)}^i\right)^2.$$

Therefore, for the observed prediction variance to increase with the variance in the preliminary version j, we must have $\hat{\beta}^{i*} < -0.5$. If $\hat{\beta}_1^{i*} = 0$, we have that

$$\frac{1}{N}\sum_{t\in\mathcal{T}}\left(y_{t,(j)}^i - \bar{y}_{(j)}^i\right)^2 = \frac{1}{N}\sum_{t\in\mathcal{T}}\left(y_{t,(4)}^i - \bar{y}_{(4)}^i\right)^2 - \frac{1}{N}\sum_{t\in\mathcal{T}}\left(e_{t,(j)}^i - \hat{\mu}_{(j)}^i\right)^2 \leq \frac{1}{N}\sum_{t\in\mathcal{T}}\left(y_{t,(4)}^i - \bar{y}_{(4)}^i\right)^2,$$

the variance in preliminary figures must be smaller than the variance in the final figures. Thus, the test of $\beta_1^* = 0$ (or the (more common) joint test of $\beta_0 = 0$ combined with $\beta_1^* = 0$) is also a test of whether the revision from vintage j to the final vintage contains "news", see Mankiw et al. (1984) and Croushore and Stark (2003). Furthermore, if $PV_j^i = \frac{1}{N}\sum_{t\in\mathcal{T}}\left(e_{t,(j)}^i - \bar{e}_{(j)}^i\right)^2$ decreases with the vintage figure (as is the case for most variables in Table 3), it follows that $\frac{1}{N}\sum_{t\in\mathcal{T}}\left(y_{t,(j)}^i - \bar{y}_{(j)}^i\right)^2$ increases with the vintage figure. Since PV_j^i decreases with the vintage figure for most variables (as can be seen from Table 3), the test of $\beta_1^* = 0$ also becomes a test of whether each revision step contains "news".

The hypothesis of $\beta_1 = 1 \Leftrightarrow \beta_1^* = 0$ can be tested by defining $d_t^i = \left(e_{t,(j)}^i - \hat{\mu}_{(j)}^i\right)\left(y_{t,(j)}^i - \bar{y}_{t,(j)}^i\right)$ (since $\bar{d}^i$ is the nominator of the estimator for β_1^*) and applying (5). The joint test for all variables in a version is conducted by defining $\mathbf{d}_t = \left(d_t^1, d_t^2, \ldots, d_t^K\right)'$ and applying (7). Table 5 reports the results (see

Table 5: Test of efficiency in preliminary figures,1988-2017 (adjusted preliminary figures)

	Vintage 1 ($N = 30$)				Vintage 2 ($N = 30$)				Vintage 3 ($N = 22$)			
Variable	$\hat{\beta}_1^*$	std. err.	test st.	p-val.	$\hat{\beta}_1^*$	std. err.	test st.	p-val.	$\hat{\beta}_1^*$	std. err.	test st.	p-val.
GDP	-0.04	0.06	-0.61	0.54	-0.04	0.05	-0.71	0.48	-0.00	0.06	-0.00	1.00
GDPM	0.05	0.10	0.55	0.59	0.01	0.08	0.10	0.92	-0.03	0.05	-0.67	0.51
CP	0.06	0.11	0.59	0.56	0.02	0.08	0.21	0.84	0.03	0.04	0.84	0.41
CO	-0.16	0.18	-0.87	0.39	-0.16	0.08	-2.06	0.05*	-0.02	0.11	-0.20	0.84
J	-0.00	0.05	-0.03	0.98	-0.02	0.06	-0.28	0.78	-0.02	0.06	-0.41	0.68
JK	0.02	0.03	0.68	0.50	0.03	0.04	0.71	0.48	0.03	0.05	0.66	0.52
EX	-0.02	0.06	-0.30	0.77	0.02	0.03	0.89	0.38	-0.04	0.06	-0.65	0.52
IMP	-0.06	0.05	-1.19	0.24	-0.05	0.04	-1.42	0.17	-0.05	0.04	-1.11	0.28
All (F-test)	..	..	0.95	0.50	..	..	1.91	0.10	..	..	0.94	0.51
All (t-test)	-0.02	0.03	-0.65	0.51	-0.00	0.02	-0.07	0.94	-0.01	0.01	-0.85	0.40
All exc. JK (F-test)	..	..	1.07	0.41	..	..	2.19	0.07	..	..	0.91	0.52
All exc. JK (t-test)	-0.02	0.03	-0.77	0.44	-0.01	0.02	-0.29	0.77	-0.01	0.01	-1.29	0.20

Testing the null hypothesis of $\beta_1^* = 0$ in the regression $e^{i*}_{t,(j)} = \beta_0 + \beta_1^* y^i_{t,(j)} + v^i_{t,(j)}$, where $e^{i*}_{t,(j)}$ is the adjusted difference between vintage j and the final vintage of a national account figure or vector of those figures. All tests where standard error (std. err.) is reported are t-tests with $N-1$ degrees of freedom when one variable is tested and $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested; otherwise the tests are F-tests with K degrees of freedom in the nominator and $N-1$ degrees of freedom in the denominator.

also Table A3 and Table A8).

If we under the alternative model imposes the restriction that β_1^* is equal across all variables ($\beta_1^{1*} = \beta_1^{2*} = \cdots = \beta_1^{K*}$), then the test of the hypothesis that this common parameter is equal to zero can be formulated by defining

$$d_t = \left(\mathbf{y}_{t,(j)} - \bar{\mathbf{y}}_{t,(j)}\right)' \tilde{\Omega}^{-1} \left(\mathbf{e}_{t,(j)} - \bar{\mathbf{e}}_{(j)}\right)$$

$$\text{where } \mathbf{y}_{t,(j)} = \left(y^1_{t,(j)}, y^1_{t,(j)}, \ldots, y^K_{t,(j)}\right)', \bar{\mathbf{y}}_{(j)} = \left(\bar{y}^1_{(j)}, \bar{y}^1_{(j)}, \ldots, \bar{y}^K_{(j)}\right)',$$

$$\mathbf{e}_{t,(j)} = \left(e^1_{t,(j)}, e^1_{t,(j)}, \ldots, e^K_{t,(j)}\right)', \bar{\mathbf{e}}_{(j)} = \left(\bar{e}^1_{(j)}, \bar{e}^1_{(j)}, \ldots, \bar{e}^K_{(j)}\right)', \text{ and}$$

$$\tilde{\Omega} = N^{-1} \sum_{t \in \mathcal{T}} \left(\mathbf{e}_{t,(j)} - \bar{\mathbf{e}}_{(j)}\right) \left(\mathbf{e}_{t,(j)} - \bar{\mathbf{e}}_{(j)}\right)',$$

and using the test statistic given in (5), which is assumed to be t-distributed with $NK-1$ degrees of freedom. This follows from an analog derivation of the test statistic for the simplified encompassing test in Hungnes (2018).

The usual approach when applying the Mincer and Zarnowitz (1969) regression is to test the joint hypothesis $\beta_0^i = 0$ and $\beta_1^i = 1$. Here, we consider these tests separately, as we are reporting results of testing $\beta_1^i = 1$ in Table 5, and test results related to the hypothesis $\beta_0^i = 0$ conditioned on $\beta_1^i = 1$ are reported in Table 4.

With one exception we reject the null hypothesis of $\beta_1^{*i} = 0$. Thus — since we concluded that the results in Table 4 indicate that the preliminary figures also are unbiased for all variables excluding JK — the results indicate that preliminary figures are both unbiased and efficient for these variables.

We apply two different tests for testing the null hypothesis of joint efficiency. In the F-test we allow the individual β_1^{*i} to differ across variables under the alternative hypothesis. Using the t-test this parameter is restricted to be equal under the alterative hypothesis. The advantage of the latter test, is that we get more information to conduct inference. For both these tests we reject the null hypothesis of $\beta_1^{*i} = 0, \forall i$, which implies that considered jointly the preliminary figures are efficient estimates of the final vintage of the NA figures.

3.4 Encompassing

Bates and Granger (1969) and Chong and Hendry (1986) suggest an encompassing test that can be used to test whether one vintage of the data is inferior to a later vintage of the data, i.e., the first of the two vintages contains no additional information. Consider two different vintages of of the value for variable i in year t; denoted $y^i_{t,(j_1)}$ and $y^i_{t,(j_2)}$, where $1 \leq j_2 < j_1 \leq 3$ such that j_1 represents the latest vintage. Then, consider the "composite artificial model"

$$y^i_{t,(4)} = (1-\alpha)\, y^i_{t,(j_1)} + \alpha y^i_{t,(j_2)} + u^i_{t,(j_1,j_2)}, \tag{10}$$

which is a weighted average of the values of the two preliminary vintages with weight α (for preliminary vintage j_2), $u^i_{t,(j_1,j_2)}$ is an error term.[7] The encompassing test of the hypothesis $\alpha = 0$ investigates whether vintage j_1 contains all information (i.e., there is no additional information in vintage j_2). This test can be considered as an alternative test for efficiency to the one considered in Table 5; if the latter vintage of the variables is efficient its prediction cannot be improved by using an earlier vintage of the same variable.

Note that if we subtract $y^i_{t,(j_1)}$ on both sides of (10) we get the formulation

$$e^i_{t,(j_1)} = \alpha \left(e^i_{t,(j_1)} - e^i_{t,(j_2)} \right) + u^i_{t,(j_1,j_2)}. \tag{11}$$

Harvey et al. (1998) show that test of encompassing based on (10) or (11) is related to the equal predictability test put forward by Diebold and Mariano (1995), see Harvey et al. (1998). Define

$$d^i_{(a),t,(j_1,j_2)} = \left(e^i_{t,(j_1)} - e^i_{t,(j_2)} \right) u^i_{(a),t,(j_1,j_2)}, \tag{12}$$

where

$$u^i_{(a),t,(j_1,j_2)} = e^i_{t,(j_1)} - a \left(e^i_{t,(j_1)} - e^i_{t,(j_2)} \right) \tag{13}$$

[7] See Ericsson (1993) for a discussion of why this formulation of the encompassing test is preferred to more general formulations in which the weights are not restricted to sum to unity and possibly an intercept is included.

Table 6: Tests for encompassing, 1988-2017 (adjusted preliminary figures)

	Vintage 2 vs. vintage 1 ($N = 28$)				Vintage 3 vs. vintage 2 ($N = 25$)				Vintage 3 vs. vintage 1 ($N = 30$)			
Variable	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.
GDP	-0.33	0.53	-0.63	0.54	-0.17	0.17	-0.97	0.34	-0.04	0.11	-0.31	0.76
GDPM	-0.21	0.44	-0.48	0.64	-0.02	0.14	-0.14	0.89	0.00	0.12	0.03	0.98
CP	-0.08	0.50	-0.16	0.87	-0.14	0.09	-1.64	0.11	-0.07	0.11	-0.62	0.54
CO	0.40	0.15	2.64	0.01*	-0.65	0.85	-0.76	0.45	0.15	0.19	0.78	0.44
J	0.22	0.17	1.33	0.20	0.16	0.19	0.86	0.40	0.22	0.11	2.03	0.05
JK	0.71	0.31	2.27	0.03*	0.33	0.22	1.55	0.13	0.48	0.20	2.38	0.02*
EX	-0.02	0.18	-0.10	0.92	0.54	0.42	1.27	0.22	0.11	0.12	0.93	0.36
IMP	-0.14	0.20	-0.72	0.48	0.09	0.11	0.84	0.41	0.10	0.06	1.70	0.10
All	0.11	0.05	2.17	0.03*	0.03	0.05	0.60	0.55	0.05	0.02	2.22	0.03*
All exc. JK	0.07	0.06	1.29	0.20	0.01	0.05	0.25	0.80	0.04	0.02	1.70	0.09

Testing the null hypothesis of $\alpha = 0$ in the regression $e^{i*}_{t,(j_1)} = \alpha(e^{i*}_{t,(j_1)} - e^{i*}_{t,(j_2)}) + u^i_{t,(j_1,j_2)}$, $\{j_1, j_2\} = \{2,1\}, \{3,2\}, \{3,1\}$, where $e^{i*}_{t,(j)}$ is the adjusted difference between vintage j and the final vintage of a national account figure or vector of those figures. All reported tests are t-tests with $N-1$ degrees of freedom when one variable is tested and with $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested.

is the error in (11) when $a = \alpha$. Thus, the encompassing version of the Diebold and Mariano (1995) test is based on $d^i_{(a),t,(j_1,j_2)}$ with $a = 0$, as

$$d^i_{(0),t,(j_1,j_2)} = \left(e^i_{t,(j_1)} - e^i_{t,(j_2)}\right) e^i_{t,(j_1)}. \tag{14}$$

The Diebold and Mariano (1995) test involves testing if the population equivalence of the mean of $d^i_{(0),t,(j_1,j_2)}$ is equal to zero. The corresponding test statistic is given in (5) with $d^i_t = d^i_{(0),t,(j_1,j_2)}$. The results are reported in Table 6 (see also Table A4 and Table A9). In the last line of the table, results from a vector version of the test is also reported, see Hungnes (2018). This test involves imposing the restriction that the parameter α is equal across all variables and test the null hypothesis that the value of this common parameter is equal to zero. Then we define

$$d_t = \left(\mathbf{e}_{t,(j_1)} - \mathbf{e}_{t,(j_2)}\right)' \tilde{\Omega}^{-1} \mathbf{e}_{t,(j_1)}, \text{ where } \tilde{\Omega} = \sum_{t \in \mathcal{T}} \left(\mathbf{e}_{t,(j_1)} - \mathbf{e}_{t,(j_2)}\right) \left(\mathbf{e}_{t,(j_1)} - \mathbf{e}_{t,(j_2)}\right)',$$

and apply the test statistic given in (5). This test statistic is assumed to be approximately t-distributed with $NK - 1$ degrees of freedom.

First, we test if vintage 2 encompasses vintage 1. (Here $N = 28$ as we exclude the years 1994 and 2001, as there is a benchmark revision for these two years between vintage 1 and vintage 2.) For CO we get an estimate of 0.40, implying that the best (numerical) estimate of the growth in CO after the first two vintages are published is a weighted average with 0.60 weight on vintage 2 and 0.40 weight on vintage 1. For JK, the best estimate would be with a weight of as much as 0.71 on vintage 1. However, this may be a result of how we have adjusted for benchmark revisions. When ignoring the effect of benchmark revisions we reject that the second vintage of that neither CO nor JK encompasses the first vintage, see

Table A4. And when excluding the years where an benchmark revision has taken place, we only reject that vintage 2 of CO encompasses vintage 1 at a 5 percent significance level — and with a much smaller estimate on the optimal weight of vintage 1 (see Table A9). Considered all variables jointly, we reject that vintage 2 encompasses vintage 1 (at the 5 percent significance level).[8] If we exclude gross capital formation (JK) from the joint test, we reject the null hypothesis that vintage 2 encompasses vintage 1.

Second, we test whether vintage 3 encompasses vintage 2. Table 6 shows that we neither reject the null hypothesis for encompassing for the variables individually nor jointly.

Third, we test whether vintage 3 encompasses vintage 1. Again, we reject the null hypothesis for JK. The rejection of encompassing for JK also leads to rejection of the joint test for encompassing: if we exclude JK from the vector of considered variables we do not reject the null hypothesis.

The overall conclusion we draw from Table 6, Table A4, and Table A9 is that when excluding JK the test results more or less support the null hypothesis that the latest vintage encompasses an earlier vintage, both considered individually or jointly.

3.5 Equal predictability

The equal predictability test implies testing the null hypothesis of $\alpha = 0.5$ in (11). By defining

$$d_t^i = 2d^i_{(0.5),t,(j_1,j_2)} = \left(e^i_{t,(j_1)} - e^i_{t,(j_2)}\right)\left(e^i_{t,(j_1)} + e^i_{t,(j_2)}\right) = {e^i_{t,(j_1)}}^2 - {e^i_{t,(j_2)}}^2, \tag{15}$$

we can apply the test statistic given in (5). This test statistic is assumed to be approximately t-distributed with $N-1$ degrees of freedom.

The vector version of the test is derived in Hungnes (2019), and implies restricting α to be equal across all variables and testing the null hypothesis that this common parameter is equal to one-half. To apply this test we define

$$d_t = \left(\mathbf{e}_{t,(j_1)} - \mathbf{e}_{t,(j_2)}\right)' \tilde{\Omega}^{-1}\left(\mathbf{e}_{t,(j_1)} + \mathbf{e}^i_{t,(j_2)}\right) \text{ where } \tilde{\Omega} = N^{-1}\sum_{t\in\mathcal{T}}\left(\mathbf{e}_{t,(j_1)} + \mathbf{e}_{t,(j_2)}\right)\left(\mathbf{e}_{t,(j_1)} + \mathbf{e}_{t,(j_2)}\right)'$$

and apply the test statistic given in (5). This test statistic is assumed to be approximately t-distributed with $NK-1$ degrees of freedom.

The results of these tests are reported in Table 7. For the individual tests of equal predictability we only rejects the null hypothesis of $\alpha = 0.5$ in a few cases. However, when testing this hypothesis on the vector of all variables except JK, we reject the null hypothesis of equal predicability. Furthermore, in the joint test, the point estimate of the optimal weight between the two vintages are in all three cases well

[8]However, this is only the case when we consider the preliminary figures adjusted for benchmark revisions, see Table A4 and Table A9.

Table 7: Tests for equal predictability, 1988-2017 (adjusted preliminary figures)

	Vintage 2 vs. vintage 1 ($N = 28$)				Vintage 3 vs. vintage 2 ($N = 25$)				Vintage 3 vs. vintage 1 ($N = 30$)			
Variable	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.
GDP	-0.33	0.75	-1.11	0.28	-0.17	0.29	-2.27	0.03*	-0.04	0.30	-1.77	0.09
GDPM	-0.21	0.50	-1.42	0.17	-0.02	0.28	-1.85	0.08	0.00	0.29	-1.70	0.10
CP	-0.08	0.62	-0.94	0.36	-0.14	0.18	-3.50	0.00**	-0.07	0.23	-2.42	0.02*
CO	0.40	0.13	-0.78	0.44	-0.65	0.89	-1.29	0.21	0.15	0.22	-1.58	0.13
J	0.22	0.26	-1.05	0.30	0.16	0.15	-2.33	0.03*	0.22	0.14	-1.90	0.07
JK	0.71	0.31	0.66	0.52	0.33	0.26	-0.65	0.52	0.48	0.33	-0.07	0.95
EX	-0.02	0.18	-2.83	0.01**	0.54	0.35	0.11	0.91	0.11	0.16	-2.42	0.02*
IMP	-0.14	0.41	-1.57	0.13	0.09	0.19	-2.13	0.04*	0.10	0.21	-1.96	0.06
All	0.29	0.13	-1.60	0.11	0.14	0.10	-3.45	0.00**	0.20	0.11	-2.69	0.01**
All exc. *JK*	0.18	0.15	-2.10	0.04*	0.12	0.11	-3.57	0.00**	0.13	0.12	-3.06	0.00**

Testing the null hypothesis of $\alpha = 0.5$ in the regression $e^{i*}_{t,(j_1)} = \alpha(e^{i*}_{t,(j_1)} - e^{i*}_{t,(j_2)}) + u^i_{t,(j_1,j_2)}$, $\{j_1, j_2\} = \{2,1\}, \{3,2\}, \{3,1\}$, where $e^{i*}_{t,(j)}$ is the adjusted difference between vintage j and the final vintage of a national account figure or vector of those figures. All reported tests are t-tests with $N-1$ degrees of freedom when one variable is tested and with $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested.

below 0.5. Hence, the later vintage is significantly better that an earlier vintage of the variables.

4 Conclusions

In this paper, we have investigated the revision process of national account figures in Norway. We have found that the accuracy of most of the preliminary figures increases throughout the revision process, as the root mean squared errors (RMSE) decreases throughout the revision process. For most of the variables considered here, the preliminary figures are unbiased. The exception is for gross fixed capital formations, which tend to be underestimated in all preliminary versions.

We also conducted two different tests to investigate the efficiency of the preliminary national accounts figures. The first, a variant of the Mincer and Zarnowitz (1969) test, indicates that the preliminary figures have been weakly efficient estimates of the final national account figures.

The second type of test on efficiency in the preliminary figures involves comparing different vintages of the national account figures against each other, both variable by variable but also the full vectors of the variables. First (in the opposite order in the current version of the paper), we have conducted an equal predictability test between two different vintages of a vector of the national account series that excludes gross fixed capital formation. For each pair of vintages that we have compared, we have rejected the equal predictability hypothesis, and combined with estimated parameters, we find that the most recent vintage of the preliminary national accounts data is significantly better than an earlier vintage of the data. Second, we have conducted encompassing tests for the same pairs of the preliminary vintages. The results for the variables tested separately are somewhat mixed. But when tested jointly, we cannot reject the null hypothesis that a later vintage encompasses an earlier one when we exclude gross fixed capital formation. When including gross fixed capital formation in the vector of variables we reject the null hypothesis for a majority of the compared vintages, indicating that the national account figures for this series are not optimally updated.

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A Estimation result with alternative treatment for benchmark revisions

Table A1: Accuracy in preliminary figures, 1988-2017 (full sample)

	Vintage 1 ($N = 30$)			Vintage 2 ($N = 30$)			Vintage 3 ($N = 30$)			Final vintage ($N = 30$)
Variable	$RMSE^i_{(1)}$	$\sqrt{PV^i_{(1)}}$	$\sqrt{\frac{PV^i_{(1)}}{V^i}}$	$RMSE^i_{(2)}$	$\sqrt{PV^i_{(2)}}$	$\sqrt{\frac{PV^i_{(2)}}{V^i}}$	$RMSE^i_{(3)}$	$\sqrt{PV^i_{(3)}}$	$\sqrt{\frac{PV^i_{(3)}}{V^i}}$	$\sqrt{V^i}$
GDP	0.86	0.85	0.53	0.76	0.76	0.45	0.61	0.60	0.40	1.53
GDPM	0.78	0.75	0.46	0.75	0.72	0.39	0.63	0.59	0.31	2.03
CP	0.75	0.73	0.42	0.72	0.69	0.37	0.54	0.52	0.29	1.89
CO	1.12	1.11	0.70	0.95	0.95	0.61	0.88	0.87	0.62	1.41
J	2.92	2.89	0.37	2.66	2.64	0.32	1.99	1.97	0.24	8.21
JK	4.90	4.87	0.42	3.33	3.33	0.35	2.82	2.77	0.34	8.18
EX	1.20	1.10	0.30	0.90	0.86	0.24	0.93	0.91	0.25	3.80
IMP	1.61	1.53	0.35	1.08	1.08	0.24	0.92	0.89	0.20	4.52

Root mean squared error (RMSE) and root of both the absolute and the relative forecast variance, as well as the root of the variance of the final vintage.

Table A2: Tests for absence of bias in preliminary figures, 1988-2017 (full sample)

	Vintage 1 ($N = 30$)				Vintage 2 ($N = 30$)				Vintage 3 ($N = 30$)			
Variable	$\hat{\mu}$	std. err.	test st.	p-val.	$\hat{\mu}$	std. err.	test st.	p-val.	$\hat{\mu}$	std. err.	test st.	p-val.
GDP	0.08	0.19	0.42	0.67	0.08	0.16	0.50	0.62	0.13	0.12	1.12	0.27
GDPM	0.21	0.17	1.27	0.21	0.22	0.15	1.46	0.15	0.21	0.12	1.81	0.08
CP	0.21	0.14	1.46	0.15	0.19	0.13	1.48	0.15	0.15	0.09	1.59	0.12
CO	0.10	0.20	0.48	0.64	0.00	0.20	0.00	1.00	-0.01	0.19	-0.05	0.96
J	-0.43	0.61	-0.71	0.49	-0.33	0.53	-0.62	0.54	-0.22	0.38	-0.58	0.57
JK	0.61	0.80	0.76	0.45	0.19	0.71	0.27	0.79	0.52	0.53	0.97	0.34
EX	0.48	0.23	2.11	0.04*	0.26	0.17	1.48	0.15	0.22	0.19	1.17	0.25
IMP	0.50	0.28	1.79	0.08	0.03	0.20	0.17	0.87	-0.25	0.18	-1.40	0.17
All	..	..	2.50	0.03*	..	..	2.97	0.01*	..	..	5.04	0.00**

Testing the null hypothesis of $\mu^i_{(j)} = 0$ in the regression $e^i_{t,(j)} = \mu^i_{(j)} + u^i_{t,(j)}$, where $e^i_{t,(j)}$ is the difference between vintage j and the final vintage of a national account figure or vector of those figures. All tests where standard error (std. err.) is reported are t-tests with $N-1$ degrees of freedom when one variable is tested and $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested; otherwise the tests are F-tests with K degrees of freedom in the nominator and $N-1$ degrees of freedom in the denominator.

Table A3: Test of efficiency in preliminary figures,1988-2017 (full sample)

	Vintage 1 ($N = 30$)				Vintage 2 ($N = 30$)				Vintage 3 ($N = 30$)			
Variable	$\hat{\beta}_1^*$	std. err.	test st.	p-val.	$\hat{\beta}_1^*$	std. err.	test st.	p-val.	$\hat{\beta}_1^*$	std. err.	test st.	p-val.
GDP	-0.02	0.07	-0.35	0.73	-0.05	0.06	-0.87	0.39	0.01	0.06	0.16	0.87
GDPM	0.05	0.11	0.41	0.68	-0.02	0.10	-0.23	0.82	-0.06	0.06	-0.91	0.37
CP	0.04	0.13	0.28	0.78	-0.01	0.10	-0.09	0.93	0.01	0.06	0.13	0.90
CO	-0.23	0.22	-1.02	0.31	-0.15	0.11	-1.37	0.18	-0.06	0.14	-0.44	0.66
J	-0.00	0.05	-0.05	0.96	-0.02	0.06	-0.37	0.71	-0.02	0.04	-0.50	0.62
JK	-0.21	0.17	-1.28	0.21	-0.08	0.08	-0.99	0.33	0.00	0.04	0.09	0.93
EX	-0.06	0.06	-1.09	0.29	-0.03	0.04	-0.94	0.35	-0.04	0.05	-0.90	0.37
IMP	-0.01	0.08	-0.09	0.93	-0.00	0.06	-0.03	0.97	-0.00	0.03	-0.04	0.97
All (F-test)	..	..	0.97	0.48	..	..	1.16	0.35	..	..	1.30	0.28
All (t-test)	-0.03	0.03	-0.91	0.36	-0.03	0.02	-1.21	0.22	-0.02	0.02	-0.86	0.39

Testing the null hypothesis of $\beta_1^* = 0$ in the regression $e^i_{t,(j)} = \beta_0 + \beta_1^* y^i_{t,(j)} + v^i_{t,(j)}$, where $e^i_{t,(j)}$ is the difference between vintage j and the final vintage of a national account figure or vector of those figures. All tests where standard error (std. err.) is reported are t-tests with $N-1$ degrees of freedom when one variable is tested and $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested; otherwise the tests are F-tests with K degrees of freedom in the nominator and $N-1$ degrees of freedom in the denominator.

Table A4: Tests for encompassing, 1988-2017 (full sample)

	Vintage 2 vs. vintage 1 ($N = 30$)				Vintage 3 vs. vintage 2 ($N = 30$)				Vintage 3 vs. vintage 1 ($N = 30$)			
Variable	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.
GDP	-0.36	0.49	-0.74	0.46	-0.18	0.25	-0.73	0.47	-0.11	0.13	-0.90	0.38
GDPM	0.25	0.46	0.53	0.60	-0.02	0.20	-0.10	0.92	0.12	0.20	0.60	0.55
CP	-0.01	0.63	-0.02	0.98	-0.15	0.14	-1.05	0.30	-0.04	0.15	-0.25	0.80
CO	0.19	0.19	1.03	0.31	-0.09	0.73	-0.12	0.91	0.12	0.24	0.53	0.60
J	0.30	0.17	1.79	0.08	0.12	0.16	0.71	0.48	0.22	0.11	1.97	0.06
JK	-0.03	0.10	-0.26	0.79	0.32	0.17	1.87	0.07	0.17	0.10	1.65	0.11
EX	0.07	0.18	0.37	0.71	0.55	0.33	1.65	0.11	0.27	0.16	1.70	0.10
IMP	-0.13	0.22	-0.61	0.55	0.31	0.17	1.77	0.09	0.18	0.08	2.29	0.03*
All	0.06	0.08	0.82	0.41	0.14	0.07	1.99	0.05*	0.12	0.04	3.25	0.00**

Testing the null hypothesis of $\alpha = 0$ in the regression $e^i_{t,(j_1)} = \alpha(e^i_{t,(j_1)} - e^i_{t,(j_2)} + u^i_{t,(j_1,j_2)})$, $\{j_1, j_2\} = \{2,1\}, \{3,2\}, \{3,1\}$, where $e^i_{t,(j)}$ is the difference between vintage j and the final vintage of a national account figure or vector of those figures. All reported tests are t-tests with $N-1$ degrees of freedom when one variable is tested and with $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested.

Table A5: Tests for equal predictability, 1988-2017 (full sample)

	Vintage 2 vs. vintage 1 ($N = 30$)				Vintage 3 vs. vintage 2 ($N = 30$)				Vintage 3 vs. vintage 1 ($N = 30$)			
Variable	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.
GDP	-0.36	0.67	-1.30	0.21	-0.18	0.34	-1.99	0.06	-0.11	0.31	-1.97	0.06
GDPM	0.25	0.41	-0.61	0.55	-0.02	0.30	-1.75	0.09	0.12	0.30	-1.27	0.21
CP	-0.01	0.72	-0.71	0.48	-0.15	0.21	-3.12	0.00**	-0.04	0.23	-2.35	0.03*
CO	0.19	0.22	-1.37	0.18	-0.09	0.73	-0.80	0.43	0.12	0.26	-1.43	0.16
J	0.30	0.27	-0.74	0.47	0.12	0.17	-2.22	0.03*	0.22	0.15	-1.93	0.06
JK	-0.03	0.42	-1.24	0.22	0.32	0.20	-0.94	0.36	0.17	0.26	-1.26	0.22
EX	0.07	0.19	-2.27	0.03*	0.55	0.21	0.23	0.82	0.27	0.13	-1.72	0.10
IMP	-0.13	0.41	-1.53	0.14	0.31	0.16	-1.23	0.23	0.18	0.19	-1.65	0.11
All	0.18	0.13	-2.44	0.01*	0.30	0.08	-2.67	0.01**	0.20	0.09	-3.41	0.00**

Testing the null hypothesis of $\alpha = 0.5$ in the regression $e^i_{t,(j_1)} = \alpha(e^i_{t,(j_1)} - e^i_{t,(j_2)} + u^i_{t,(j_1,j_2)})$, $\{j_1, j_2\} = \{2,1\}, \{3,2\}, \{3,1\}$, where $e^i_{t,(j)}$ is the difference between vintage j and the final vintage of a national account figure or vector of those figures. All reported tests are t-tests with $N-1$ degrees of freedom when one variable is tested and with $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested.

Table A6: Accuracy in preliminary figures, 1988-2017 (excluding main revisions)

Variable	Vintage 1 ($N=15$) $RMSE^i_{(1)}$	$\sqrt{PV^i_{(1)}}$	$\sqrt{\frac{PV^i_{(1)}}{V^i}}$	Vintage 2 ($N=15$) $RMSE^i_{(2)}$	$\sqrt{PV^i_{(2)}}$	$\sqrt{\frac{PV^i_{(2)}}{V^i}}$	Vintage 3 ($N=15$) $RMSE^i_{(3)}$	$\sqrt{PV^i_{(3)}}$	$\sqrt{\frac{PV^i_{(3)}}{V^i}}$	Final vintage ($N=15$) $\sqrt{V^i}$
GDP	0.84	0.82	0.35	0.68	0.67	0.28	0.38	0.38	0.15	2.52
GDPM	0.74	0.74	0.29	0.60	0.60	0.22	0.38	0.38	0.13	3.00
CP	0.66	0.65	0.22	0.61	0.61	0.19	0.40	0.40	0.12	3.36
CO	0.57	0.57	0.21	0.57	0.54	0.21	0.51	0.47	0.19	2.63
J	3.07	3.03	0.41	2.54	2.54	0.34	2.15	2.13	0.26	8.16
JK	2.89	2.54	0.31	2.81	1.99	0.29	2.73	2.25	0.29	9.39
EX	1.29	1.22	0.29	0.85	0.84	0.21	0.99	0.97	0.22	4.60
IMP	1.83	1.61	0.35	1.00	0.99	0.19	0.76	0.74	0.16	4.86

Root mean squared error (RMSE) and root of both the absolute and the relative forecast variance, as well as the root of the variance of the final vintage.

Table A7: Tests for absence of bias in preliminary figures, 1988-2017 (excluding main revisions)

	Vintage 1 ($N=15$)				Vintage 2 ($N=15$)				Vintage 3 ($N=15$)			
Variable	$\hat{\mu}$	std. err.	test st.	p-val.	$\hat{\mu}$	std. err.	test st.	p-val.	$\hat{\mu}$	std. err.	test st.	p-val.
GDP	-0.17	0.26	-0.65	0.53	-0.09	0.19	-0.46	0.65	0.02	0.08	0.25	0.81
GDPM	-0.07	0.22	-0.30	0.77	0.01	0.17	0.08	0.94	0.01	0.08	0.16	0.87
CP	-0.09	0.19	-0.46	0.65	-0.03	0.17	-0.19	0.85	0.02	0.10	0.19	0.85
CO	0.02	0.12	0.17	0.87	-0.19	0.15	-1.28	0.22	-0.20	0.13	-1.48	0.16
J	-0.47	0.90	-0.53	0.61	-0.05	0.68	-0.08	0.94	-0.29	0.57	-0.52	0.61
JK	1.37	0.55	2.51	0.02*	1.98	0.50	3.96	0.00**	1.54	0.61	2.54	0.02*
EX	0.43	0.38	1.14	0.27	0.15	0.25	0.59	0.56	0.21	0.28	0.76	0.46
IMP	0.86	0.42	2.07	0.06	0.15	0.28	0.55	0.59	-0.15	0.22	-0.69	0.50
All	..	..	3.62	0.02*	..	..	8.76	0.00**	..	..	2.96	0.04*

Testing the null hypothesis of $\mu^i_{(j)} = 0$ in the regression $e^i_{t,(j)} = \mu^i_{(j)} + u^i_{t,(j)}$, where $e^i_{t,(j)}$ is the difference between vintage j and the final vintage of a national account figure or vector of those figures. All tests where standard error (std. err.) is reported are t-tests with $N-1$ degrees of freedom when one variable is tested and $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested; otherwise the tests are F-tests with K degrees of freedom in the nominator and $N-1$ degrees of freedom in the denominator.

Table A8: Test of efficiency in preliminary figures,1988-2017 (excluding main revisions)

	Vintage 1 ($N = 15$)				Vintage 2 ($N = 15$)				Vintage 3 ($N = 15$)			
Variable	$\hat{\beta}_1^*$	std. err.	test st.	p-val.	$\hat{\beta}_1^*$	std. err.	test st.	p-val.	$\hat{\beta}_1^*$	std. err.	test st.	p-val.
GDP	-0.00	0.11	-0.01	0.99	-0.00	0.08	-0.04	0.97	-0.02	0.04	-0.53	0.61
GDPM	0.06	0.13	0.49	0.63	0.04	0.10	0.36	0.72	-0.02	0.03	-0.51	0.62
CP	0.05	0.09	0.58	0.57	0.02	0.06	0.36	0.72	0.01	0.03	0.50	0.63
CO	-0.01	0.04	-0.30	0.77	-0.04	0.05	-0.74	0.47	-0.00	0.05	-0.03	0.98
J	0.04	0.12	0.31	0.76	0.04	0.12	0.30	0.77	-0.02	0.08	-0.30	0.77
JK	0.03	0.05	0.60	0.56	0.02	0.02	0.95	0.36	0.03	0.05	0.59	0.57
EX	-0.06	0.09	-0.65	0.52	-0.01	0.06	-0.08	0.94	-0.05	0.09	-0.61	0.55
IMP	-0.09	0.09	-0.99	0.34	-0.06	0.07	-1.00	0.33	-0.02	0.04	-0.40	0.70
All (*F*-test)	..	..	0.78	0.63	..	..	0.56	0.79	..	..	0.38	0.91
All (*t*-test)	-0.01	0.01	-0.72	0.47	-0.02	0.01	-1.38	0.17	-0.01	0.01	-1.25	0.21

Testing the null hypothesis of $\beta_1^* = 0$ in the regression $e^i_{t,(j)} = \beta_0 + \beta_1^* y^i_{t,(j)} + v^i_{t,(j)}$, where $e^i_{t,(j)}$ is the difference between vintage j and the final vintage of a national account figure or vector of those figures. All tests where standard error (std. err.) is reported are t-tests with $N-1$ degrees of freedom when one variable is tested and $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested; otherwise the tests are F-tests with K degrees of freedom in the nominator and $N-1$ degrees of freedom in the denominator.

Table A9: Tests for encompassing, 1988-2017 (excluding main revisions)

	Vintage 2 vs. vintage 1 ($N = 15$)				Vintage 3 vs. vintage 2 ($N = 15$)				Vintage 3 vs. vintage 1 ($N = 15$)			
Variable	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.
GDP	-0.34	0.44	-0.76	0.46	-0.15	0.13	-1.16	0.27	-0.04	0.10	-0.41	0.69
GDPM	-0.21	0.30	-0.71	0.49	0.04	0.13	0.34	0.74	0.00	0.11	0.02	0.98
CP	-0.07	0.37	-0.18	0.86	-0.11	0.05	-1.98	0.07	-0.07	0.06	-1.25	0.23
CO	0.26	0.10	2.50	0.03*	0.04	0.21	0.18	0.86	0.16	0.06	2.45	0.03*
J	0.21	0.16	1.34	0.20	0.12	0.12	1.01	0.33	0.19	0.08	2.30	0.04*
JK	0.02	0.03	0.77	0.46	0.08	0.06	1.48	0.16	0.03	0.02	1.56	0.14
EX	0.03	0.15	0.21	0.84	0.21	0.17	1.19	0.25	0.08	0.09	0.99	0.34
IMP	-0.13	0.20	-0.66	0.52	0.05	0.09	0.59	0.56	0.07	0.05	1.37	0.19
All	0.03	0.02	1.14	0.26	0.04	0.03	1.59	0.11	0.04	0.02	2.66	0.01**

Testing the null hypothesis of $\alpha = 0$ in the regression $e^i_{t,(j_1)} = \alpha(e^i_{t,(j_1)} - e^i_{t,(j_2)} + u^i_{t,(j_1,j_2)})$, $\{j_1, j_2\} = \{2,1\}, \{3,2\}, \{3,1\}$, where $e^i_{t,(j)}$ is the difference between vintage j and the final vintage of a national account figure or vector of those figures. All reported tests are t-tests with $N-1$ degrees of freedom when one variable is tested and with $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested.

Table A10: Tests for equal predictability, 1988-2017 (excluding main revisions)

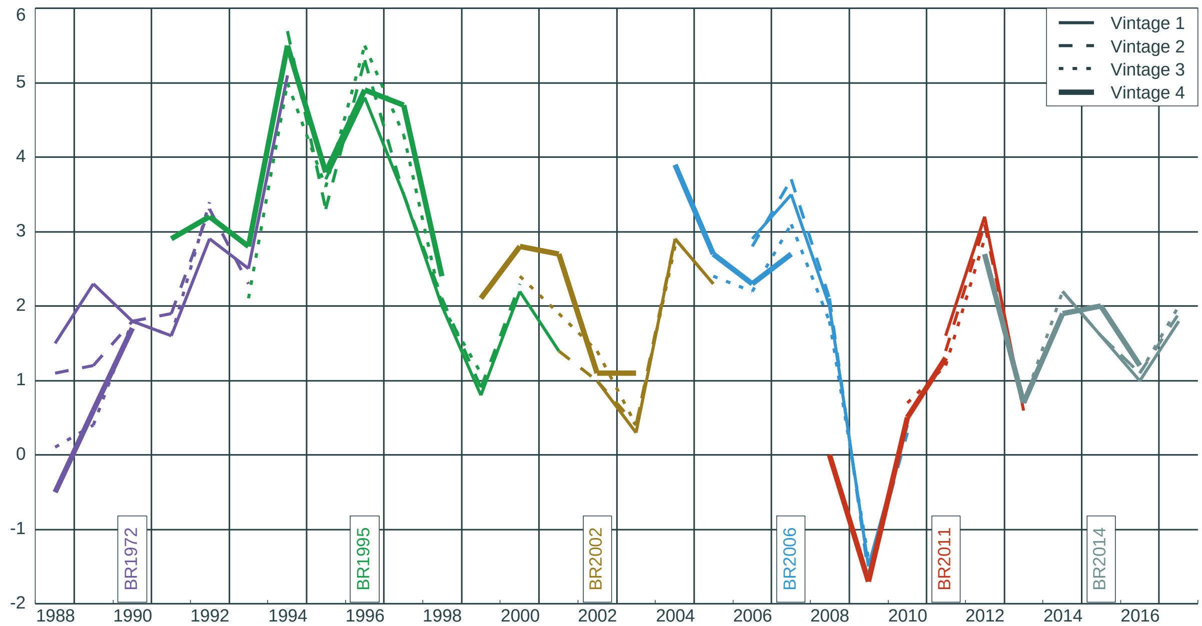
	Vintage 2 vs. vintage 1 ($N = 15$)				Vintage 3 vs. vintage 2 ($N = 15$)				Vintage 3 vs. vintage 1 ($N = 15$)			
Variable	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.	$\hat{\alpha}$	std. err.	test st.	p-val.
GDP	-0.34	0.62	-1.35	0.20	-0.15	0.25	-2.56	0.02*	-0.04	0.28	-1.90	0.08
GDPM	-0.21	0.34	-2.11	0.05	0.04	0.25	-1.79	0.09	0.00	0.26	-1.92	0.08
CP	-0.07	0.51	-1.12	0.28	-0.11	0.13	-4.73	0.00**	-0.07	0.16	-3.67	0.00**
CO	0.26	0.11	-2.28	0.04*	0.04	0.19	-2.46	0.03*	0.16	0.11	-3.13	0.01**
J	0.21	0.25	-1.17	0.26	0.12	0.13	-2.99	0.01**	0.19	0.12	-2.56	0.02*
JK	0.02	0.15	-3.08	0.01**	0.08	0.15	-2.87	0.01*	0.03	0.15	-3.09	0.01**
EX	0.03	0.15	-3.17	0.01**	0.21	0.19	-1.53	0.15	0.08	0.12	-3.43	0.00**
IMP	-0.13	0.38	-1.64	0.12	0.05	0.16	-2.89	0.01*	0.07	0.18	-2.42	0.03*
All	0.21	0.10	-3.04	0.00**	0.14	0.10	-3.63	0.00**	0.11	0.10	-3.87	0.00**

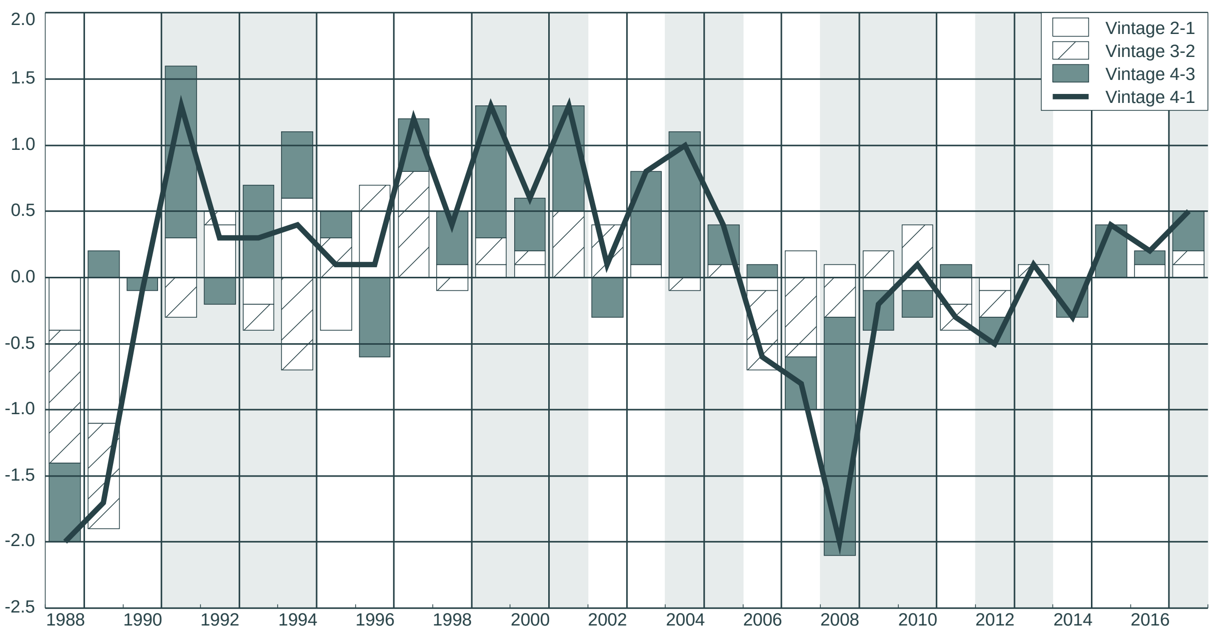
Testing the null hypothesis of $\alpha = 0.5$ in the regression $e^i_{t,(j_1)} = \alpha(e^i_{t,(j_1)} - e^i_{t,(j_2)} + u^i_{t,(j_1,j_2)})$, $\{j_1, j_2\} = \{2,1\}, \{3,2\}, \{3,1\}$, where $e^i_{t,(j)}$ is the difference between vintage j and the final vintage of a national account figure or vector of those figures. All reported tests are t-tests with $N-1$ degrees of freedom when one variable is tested and with $NK-1$ degrees of freedom when there is a joint test of all K variables that is tested.

B Graphs

The graphs below show percentage growth rates as published in the first to fourth versions (top), and associated revisions in percentage points (bottom). In the upper graph, the color code indicates which benchmark revision the different versions belong to. In the lower plot, the gray fields indicate vintages where the first and last versions were published under different benchmark revisions.

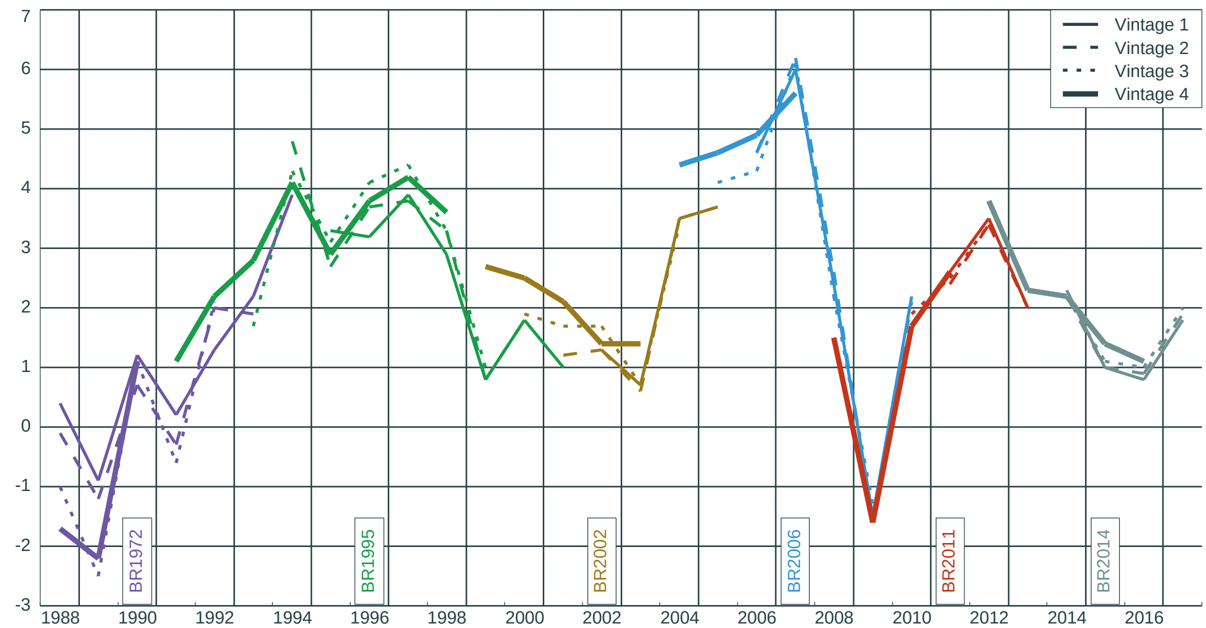
Figure B1: Gross domestic product (GDP), measured at market prices

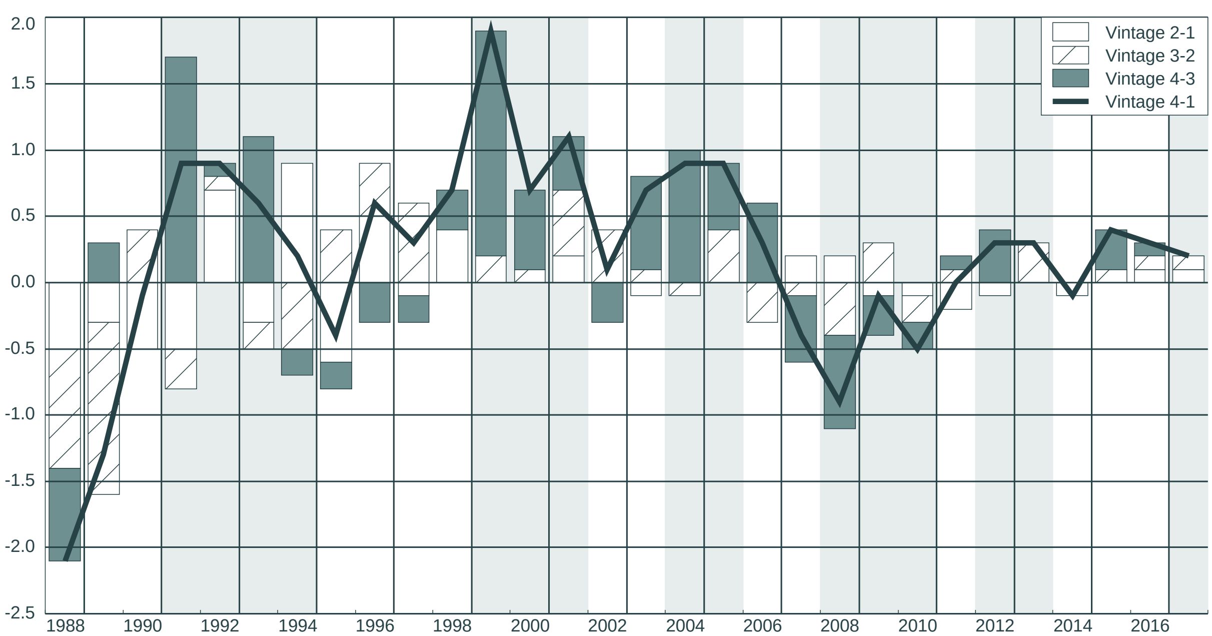




Upper part: percentage change from previous year. Lower part: revision in percentage points from on vintage to the next (bars) as well as the total revision from vintage 1 to vintage 4 (line). Source: Statistics Norway.

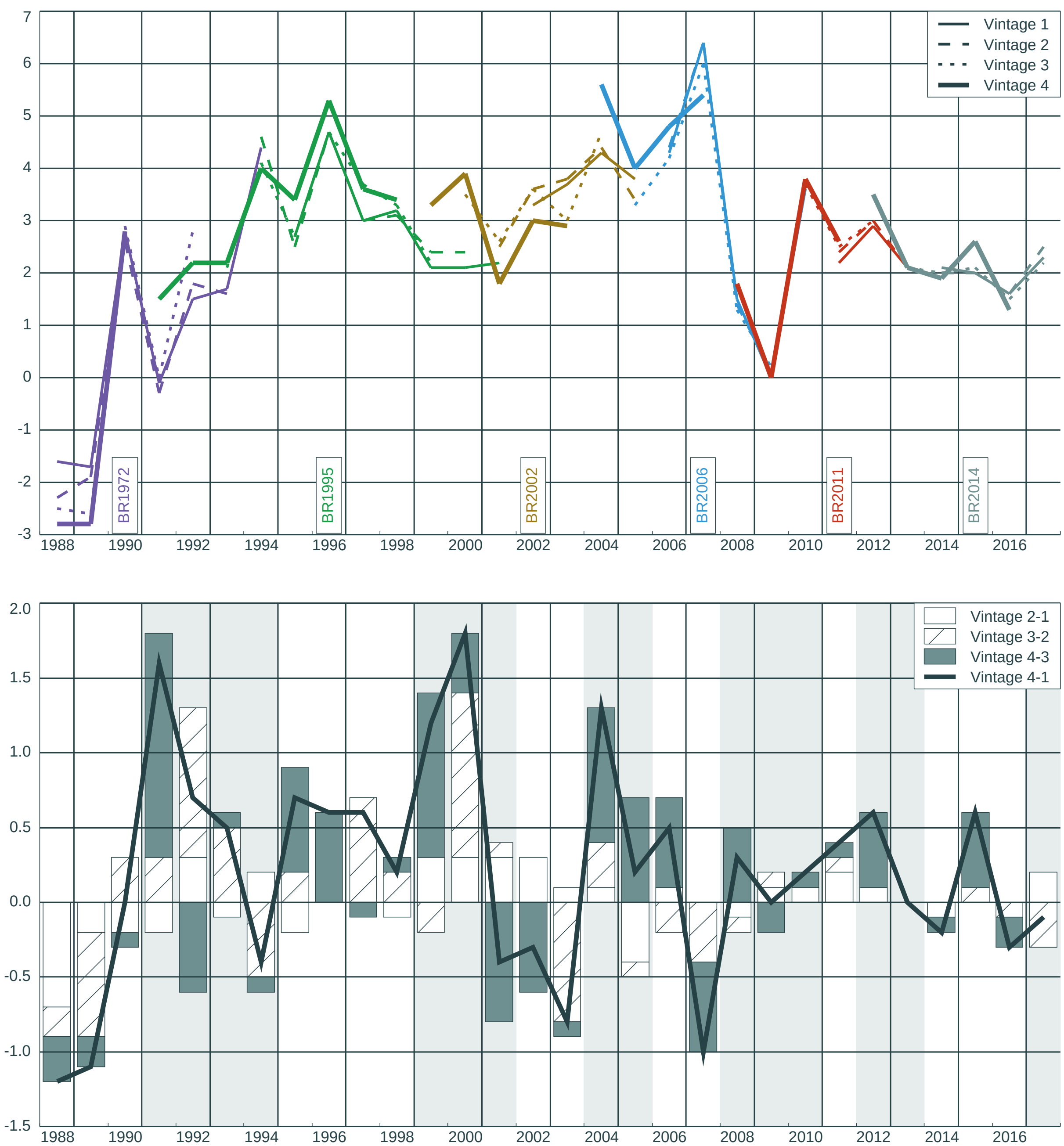
Figure B2: Gross domestic product Mainland Norway (GDPM), measured at market prices





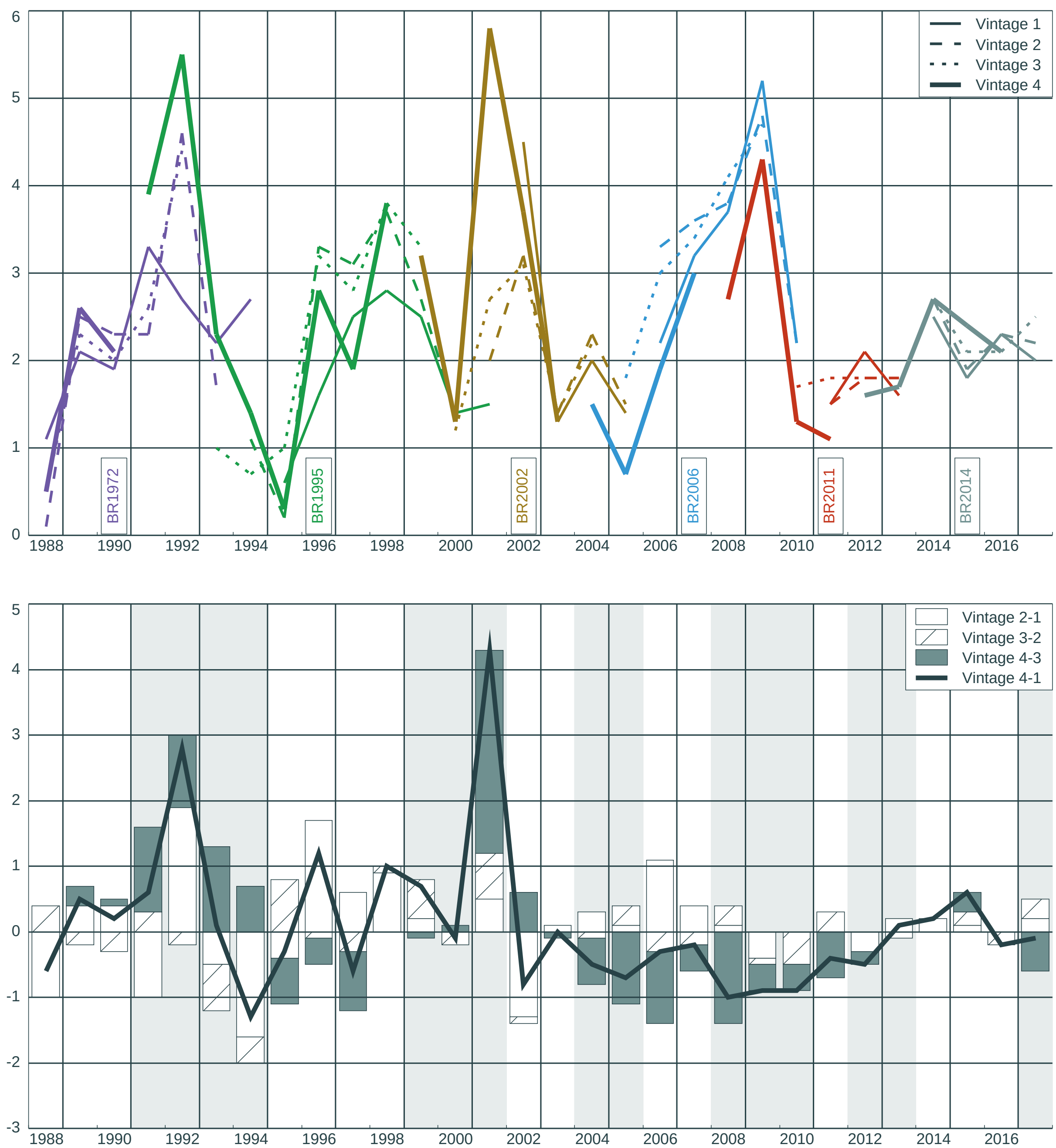
See Figure B1.

Figure B3: Private consumption (CP)



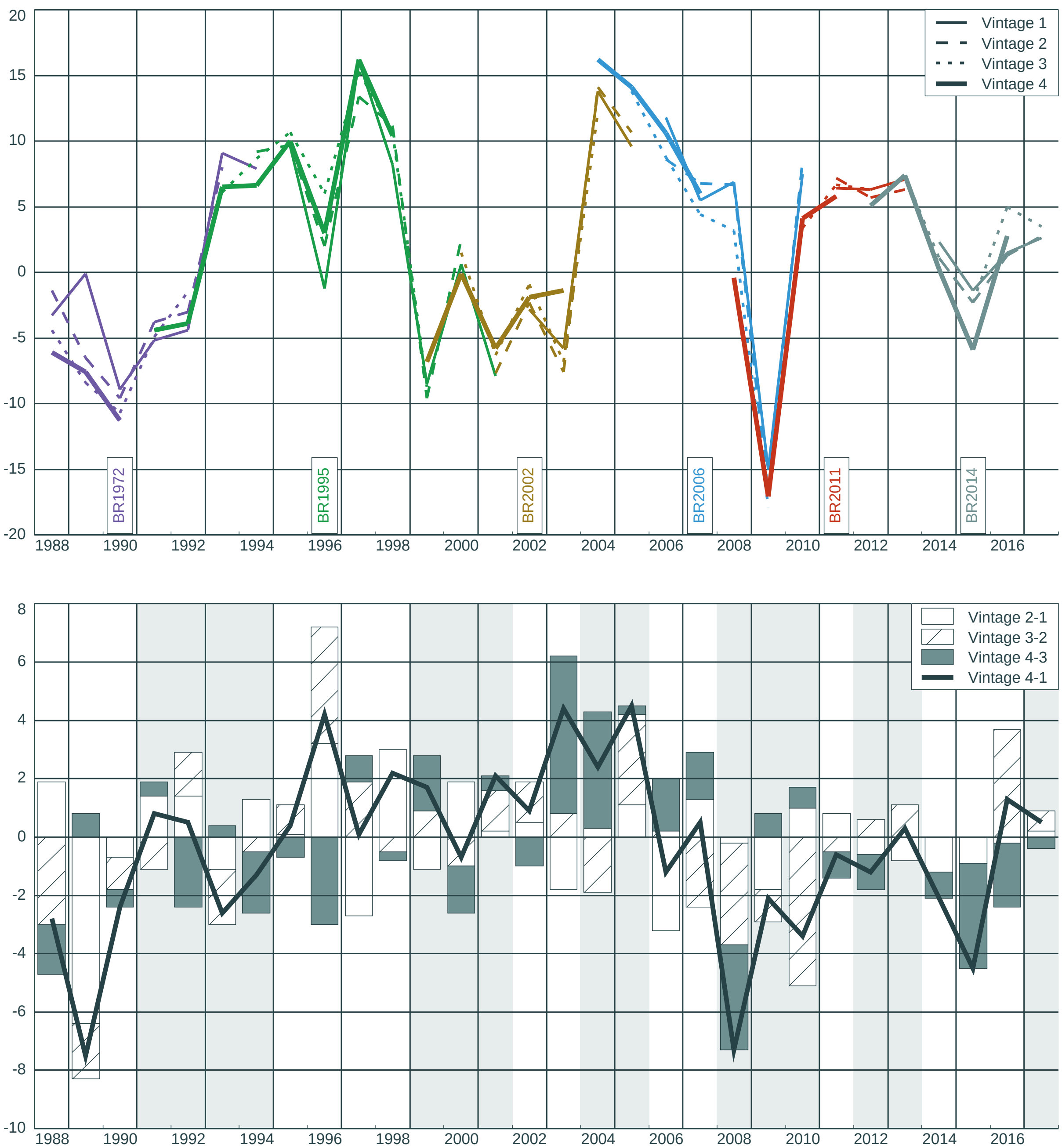
See Figure B1.

Figure B4: General government consumption (CO)



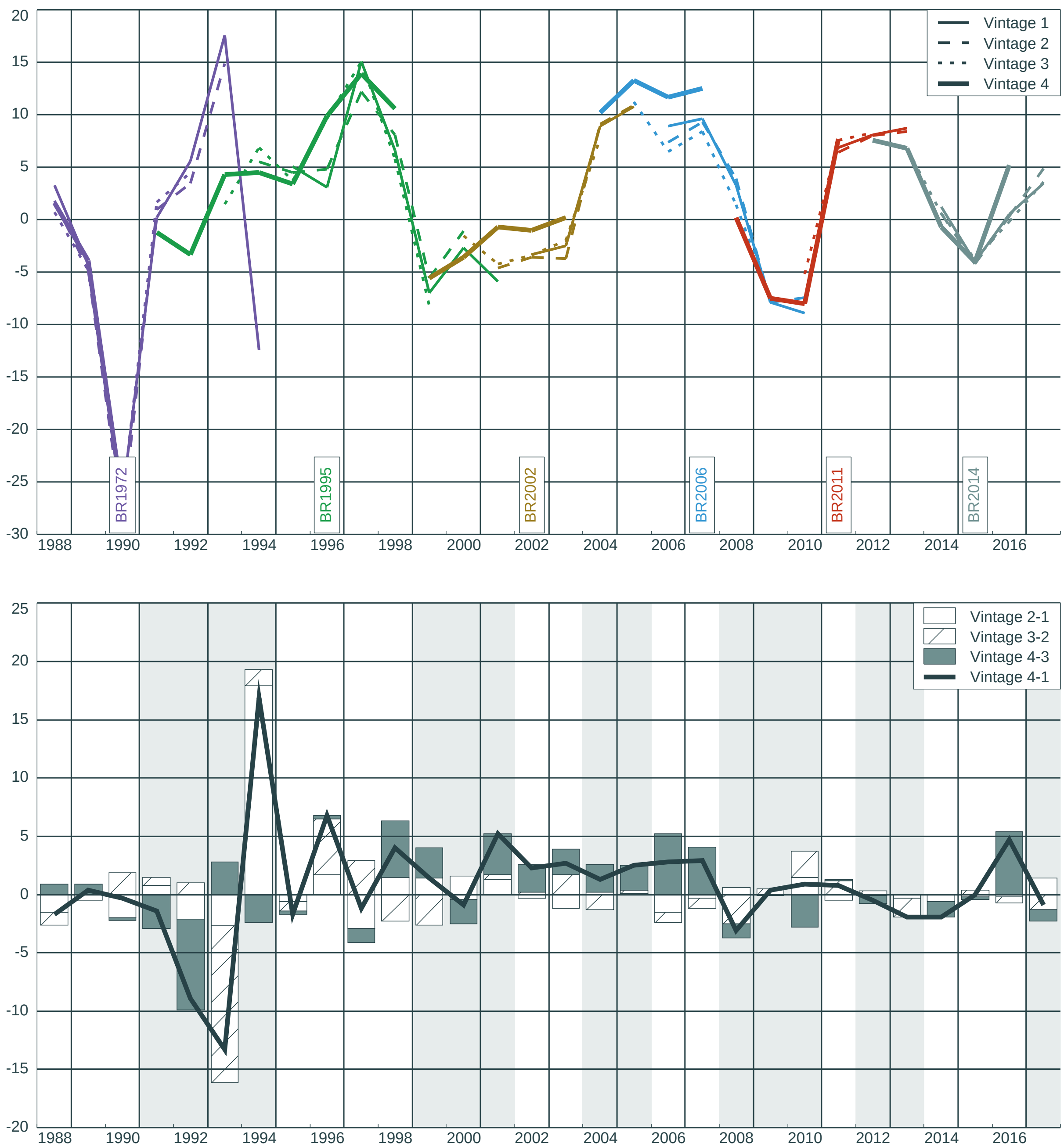
See Figure B1.

Figure B5: Gross capital formation (J)



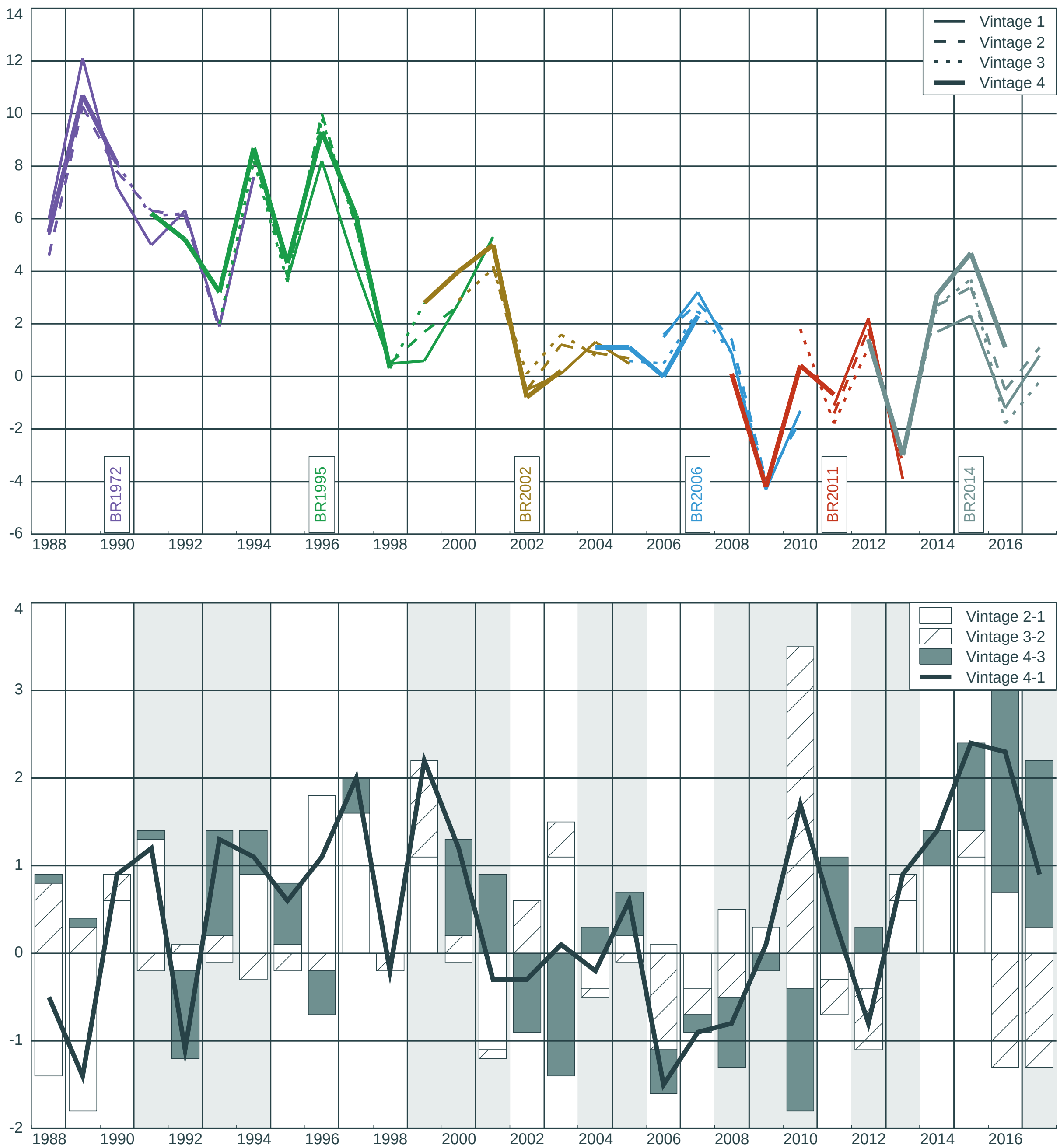
See Figure B1.

Figure B6: Gross fixed capital formation (JK)



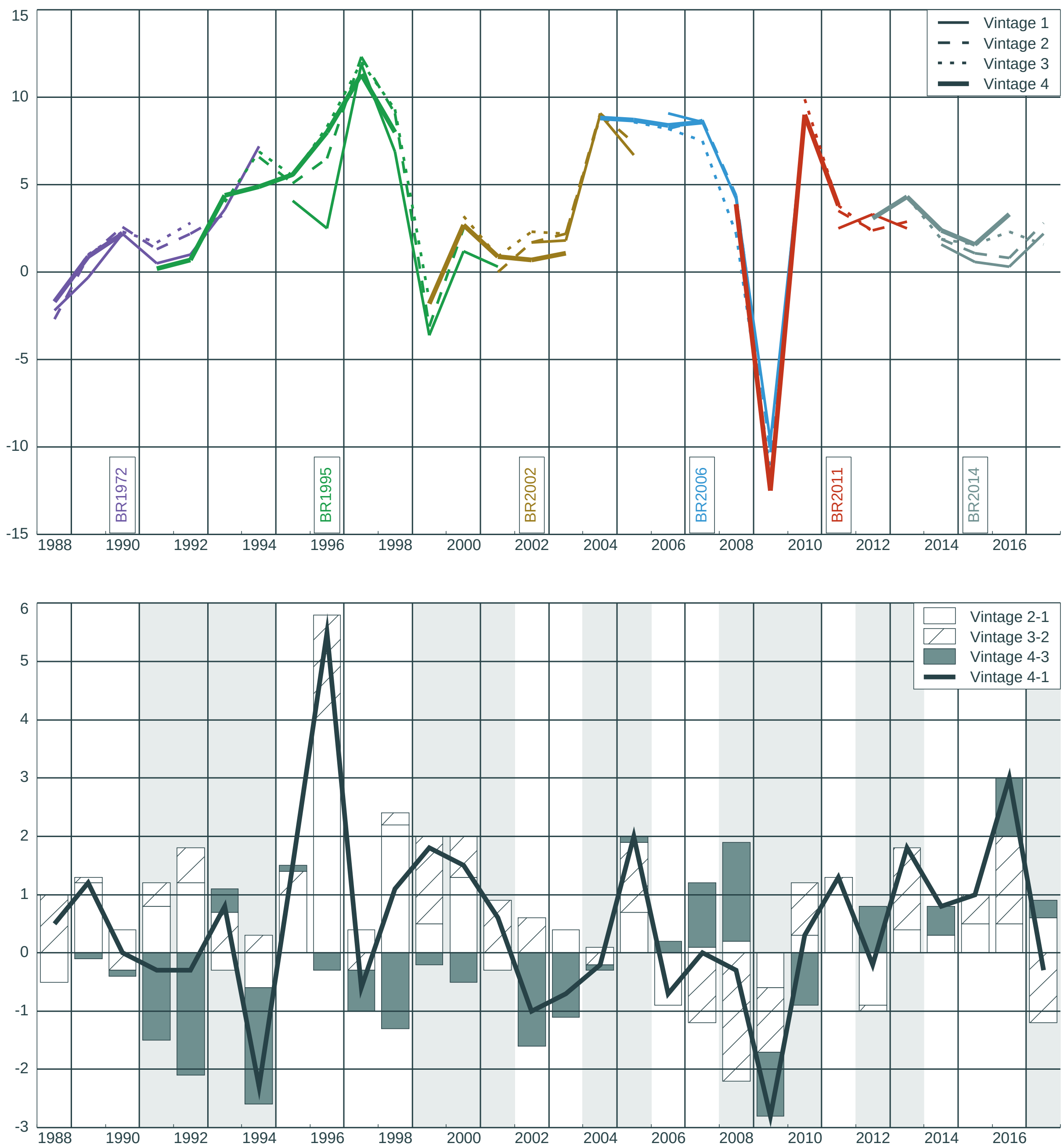
See Figure B1.

Figure B7: Total export (EX)



See Figure B1.

Figure B8: Total import (IMP)



See Figure B1.