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REVISIONS TO QUARTERLY NATIONAL ACCOUNTS DATA IN LUXEMBOURG

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Abstract

This study examines the revision histories of national accounts data in Luxembourg. I analyse first releases and revisions in the quarterly national accounts (QNA) published by the National Institute of Statistics (STATEC). Reliability is evaluated by measuring revision size, variability as well as the frequency in sign changes and acceleration/deceleration switches. In addition, the predictability of revisions is assessed by applying regression analysis. Overall, the results point to high uncertainty surrounding early QNA estimates, also in international comparison. I find that revisions to GDP and its components are substantial. While there is no clear evidence of a bias in year-on-year real GDP growth, this does not hold for some GDP components.

JEL-Codes: C82, E01, E66.
Keywords: National accounts data, real-time analysis, data revisions.

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Résumé non-technique

L'analyse de la situation économique en temps réel, l'identification de la position cyclique de l'économie et la prévision à court terme sont conditionnées par la qualité des données sous-jacentes.

Tout institut de statistique est confronté au dilemme entre la disponibilité rapide et l'exactitude des données pour la production de statistiques économiques. Des informations disponibles avec des délais importants risquent d'être moins utiles pour le diagnostic conjoncturel en temps réel, même si elles sont plus exactes. Inversement, des données qui sont rapidement disponibles peuvent faire l'objet de révisions et sont donc plus incertaines. Dans ce contexte, la rapidité et la fiabilité sont des éléments cruciaux mais contradictoires pour déterminer l'utilité des premières estimations. Pour faire un bon usage des données, il importe de connaître leur degré de fiabilité.

Cette étude porte sure les révisions des comptes nationaux au Luxembourg. Elle se base sur les premières estimations des comptes trimestriels et ses révisions successives publiées par l'Institut national de la statistique et des études économiques du Grand-Duché de Luxembourg (STATEC). L'analyse couvre les publications des comptes trimestriels sur la période allant d'avril 2006 à avril 2019. Elle se focalise sur le PIB, les principales composantes de la demande (optique dépenses du PIB), l'emploi total et la rémunération des salariés. Pour évaluer la fiabilité de ces données, des indicateurs statistiques comme la moyenne et la taille des révisions ainsi que la fréquence des changements de signe sont calculés et analysés. De plus, la prévisibilité des révisions est évaluée à l'aide d'une analyse de régression. Les résultats pour le Luxembourg sont également comparés à d'autres pays de l'OCDE.

Les résultats montrent que les estimations des comptes trimestriels au Luxembourg sont caractérisées par une incertitude élevée. Les révisions de la croissance du PIB sont importantes, et ce même après plusieurs années. Un biais systématique ne semble pas exister pour la croissance du PIB, contrairement aux estimations pour plusieurs sous-composantes du PIB. Les taux de variation de la consommation privée et publique sont en moyenne significativement révisés à la hausse. De même, les importations et les exportations font l'objet de révisions systématiques à la hausse après une période de trois ans.

Dans un contexte international, les révisions des comptes trimestriels au Luxembourg sont importantes, mais comparables à des pays comme l'Irlande, l'Estonie ou l'Islande. Ceci pourrait s'expliquer par des aspects spécifiques à l'économie luxembourgeoise, comme son degré d'ouverture, l'importance d'un secteur financier volatile ainsi que la présence de plusieurs groupes multinationaux. La compilation des comptes trimestriels est plutôt récente au Luxembourg, ce qui pourrait également être une source des révisions plutôt élevées.

1 Introduction

This study aims to examine the revision histories of national accounts data in Luxembourg. I analyse the first releases and revisions in the quarterly national accounts (QNA) published by the National Institute of Statistics (STATEC).

Early estimates of GDP and its major components are critical for a prompt analysis of economic conditions, the identification of economic developments as well as the short term forecasting of economic activity and inflation. Statistical agencies face a trade-off between timeliness and precision in the production of economic statistics. Long-delayed information is likely to be less useful despite being more accurate, while timely but imprecise data may increase uncertainty for economic agents. In this context, timeliness and reliability are crucial but conflicting elements to determine the usefulness of early estimates. First data releases are indeed subject to substantial noise, since they are based on incomplete data. In principle, the availability of new information should make estimates more accurate over time. An important information for the economist and the policymaker is thus to know to what extent national accounts data are informative at different points in the revision process. This study assesses the benefit and reliability of early estimates and their value added for economic analysis.

Since April 2006, STATEC has published Luxembourg quarterly national accounts four times a year, resulting in 52 data vintages. Based on this dataset, I analyse revisions to the different releases with the help of so-called revision triangles. The analysis will focus on the following variables: GDP (in volumes / at constant prices) and its main expenditure components (household and government consumption, gross capital formation, exports and imports) as well as total employment and compensation to employees (in nominal terms). The methodology relies on previous studies e.g. Di Fonzo (2005), Aruoba (2008), Fixler et al. (2014) and Zwijnenburg et al. (2014). Reliability can be assessed by measuring revision size, means, standard deviations and frequency of sign changes. The results are also compared with other OECD countries using the OECD real-time database. In addition the predictability of latest revisions, and hence its usefulness, can be assessed by applying regression analysis.

Results indicate high uncertainty surrounding early QNA estimates. Revisions to GDP are found to be substantial, especially for some of its components. Year-on-year growth rates of household and government expenditure tend to be revised upwards with later releases. Also revisions to imports and exports are significantly positive on average after three years. Lux-

embourg tends to have rather large revisions which can to some extent be explained by the characteristics of Luxembourg's economy and the relatively young history of QNA. However, these findings need to be interpreted with caution and further analysis of the revision process is necessary, especially as more historical data become available.

2 Literature review

The analysis of real-time data dates back to at least the 1950s.[1] Ever since, researchers have examined the properties of data revisions and how they affect different research topics, such as macroeconomic modeling, forecasting, public and monetary policy analysis. To my knowledge, only two studies deal with revisions to the national accounts data in Luxembourg.

In a recent study, Casey and Smyth (2016) examine revisions to Irish quarterly macroeconomic data and compare their results to 25 OECD countries including Luxembourg. Since Luxembourg and Ireland can both be characterised as small and very open economies with volatile economic cycles, their findings are also interesting from a Luxembourg perspective. They find that, overall, estimates of GDP tend to unbiased. However, this is not the case for some of the GDP components. The paper examines a number of factors that may explain cross-country differences in revisions: (i) the size of the economy (measured by nominal GDP), (ii) the openness of the economy (exports as % GDP), (iii) the volatility of the economic cycle (measured by the standard deviation of real GDP growth), (iv) the size of the multinational sector (measured as direct investment income inflows and outflows as % GDP) and (v) the diversity and sectoral concentration of merchandise exports (using merchandise export concentration and diversification indices produced by UNCTAD). According to their calculations, Luxembourg and Irish estimates feature the largest revisions compared to other OECD countries. Casey and Smyth (2016) do not find evidence of common factors driving revisions in their OECD sample. The analysis is exclusively based on a cross-sectional dataset and hence does not include a temporal dimension.

In a working paper by STATEC, Neumayr (2010) investigates revisions to quarterly GDP over various time horizons (from five months to at least three years after the first release) cov-

[1] For instance, Zellner (1958) compares provisional estimates in the U.S. national accounts with revised estimates. He finds consistent biases and frequent changes in direction for some items in the national accounts.

ering the period from 1995 to 2009. The analysis focuses on quarter-on-quarter growth rates of real GDP. Using different statistical indicators, the author finds that earlier estimates have been underestimated on average, indicating a directional bias. However this bias is quite small and statistically not significant. While the first revisions tend to be relatively small, the size of revisions increases with later estimates. According to Neumayr (2010), preliminary estimates tend to be reliable indicators of the direction of GDP growth. In most cases, the sign of GDP growth in the preliminary estimate remained unchanged in later revisions. In comparison with revisions data for 20 major OECD countries, Luxembourg has relatively sizeable revisions, as also found by Casey and Smyth (2016).

One major drawback of Neumayr's analysis is that it does not rely on a real-time database. The study uses observations dating back to 1995Q1 even though the first QNA estimates were only released in April 2006. This generates a bias in the results, since the time lag between the reference quarter and the first release is not constant. This data structure has a "favourable" impact on the analysis, as it reduces the size of revisions. In order to avoid this bias, this study focuses on the data for the period starting in 2005Q4, analysing the real-time revision process.

3 Data

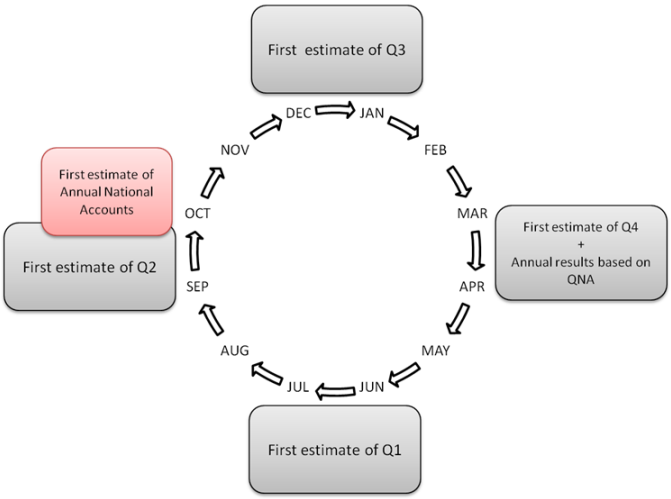
3.1 National accounts in Luxembourg

STATEC performs two independent exercises to estimate Luxembourg's national accounts. The first is based on an annual national accounts (ANA) and the second on a quarterly tool (QNA). This analysis focuses on the latter exercise since the main interest lies in early and timely estimates and their reliability to evaluate the cyclical position Luxembourg's economy. Luxembourg QNA were first published in April 2006 covering the period 1995-2005. The first estimate for the fourth quarter of 2005 and the complete set of QNA dating back to 1995 were released simultaneously.[2] The QNA are usually published within 90 days after the reference period.[3]

[2]Due to the lack of statistical sources, retropolation of data prior to 1995 is currently not available.

[3]Although, the transmission program of the European system of national and regional accounts (ESA) sets a deadline of t+70 days, Luxembourg was granted a permanent derogation setting the deadline at t+90 days. This is related to the fact that STATEC does not produce flash estimates as the European Commission requests of its Member States.

Figure 1: Release cycle of Luxembourg's national accounts



Source: STATEC, own representation.

Figure 1 depicts a typical release cycle for the national accounts estimates. The estimate relative to the first quarter is usually published in July. The estimate of the second quarter follows in October. The third quarter and the fourth quarter are usually released in January respectively April of the following year. In addition to the quarterly figures, a first estimate of annual figures based on the QNA approach is published in April.[4] The independent ANA relative to the previous year are released in October. The QNA are then revised to ensure full consistency with the ANA. Each statistical release includes the main components of GDP as the value added by industry and total employment by industry. The data is available at both current and constant prices, in unadjusted form and with seasonal and working day adjustments. A working paper by STATEC (2009) offers a detailed overview of the sources and methods used in the Luxembourg QNA (see Haas et al. (2009)) including an exhaustive list of indicators and related information on coverage, periodicity and level of detail.

Since the quarterly estimates directly depend on the availability of annual data, the degree of uncertainty varies between the quarters. Especially when estimating the first quarter of each year, usually published in July, no annual data of the previous year based on ANA is available (see figure 1). Hence, the computation of Q1 solely relies on QNA estimates of the previous year. For the second quarter, generally released in October, the initial annual estimate based on

[4] In some cases, estimates are released one month earlier.

ANA is already available.

Since the introduction of the quarterly national accounts in 2006, some methodological changes and benchmark revisions took place. The estimates in terms of volumes (constant price series) changed in the base year twice. In the second quarter of 2011, the base year switched from 2000 to 2005. In 2015, it changed a second time from 2005 to 2010. These changes affect the level of the chained volume series. Series in current prices were not affected. In theory, the change in the base year should only affect the level of the volume series but not the growth rates, as the adjustment is applied to the whole historical series.

More notably ESA 2010, a new framework for a systematic and harmonized compilation of national accounts, was implemented by all EU member states in October 2014. It replaced the previous ESA 95 framework. The main domains affected by the improvements were research and development (R&D), financial intermediation services indirectly measured (FISIM)[5], insurance, retirement pensions and the definition of the public sector. In addition, the ESA framework was harmonized with other international frameworks, namely the IMF's balance of payments manual (BPM6) and the system of national accounts (SNA) of the United Nations. STATEC published several studies on the estimated impact of these methodological changes. They found a positive effect close to 2 % on the level of nominal GDP with the strongest impact stemming from the adjustments in R&D, followed by the treatment of FISIM (see Weber and Haas (2014), Spanneut et al. (2014a, 2014b)).

In addition to the implementation of ESA 2010, STATEC conducted a major statistical benchmark revision in 2014. The main part of this revision consisted in the inclusion of illegal economic activities, mostly drug trafficking and prostitution, in Luxembourg's national accounts. In total, prostitution accounts for about 0.21 % of GDP and the illegal drugs industry accounts for 0.02% of GDP (see Weber and Emprou (2014)). These shares have remained relatively stable since 2004. The inclusion seems to have induced an upward shift in the level rather than a structural change in the growth rates.

[5]The relatively sizeable revisions on GDP in 2005 due to the implementation of a new treatment of FISIM (following regulation No 1889/2002 by European Commission) occurred prior to the introduction of the quarterly national accounts and hence do not fall within the observation period of this study.

3.2 Data structure

To analyse data revisions, data are usually set up in a specific format. The typical structure for real-time data analysis is the so-called revisions triangle presented in Figure 2. Throughout the remainder of the study, I use the standard notation in the literature on real-time data. y denotes the value of the variable under investigation. Superscripts refer to vintages (date at which the estimation is published) and subscripts define the reference time period. For example, y_t^v is the estimate available at time v of a variable y referring to period t. In this figure, each column, within which the superscript is constant, represents a vintage release with estimates referring to different time periods. As time passes, we move to the right in terms of vintages. Each row, within with the subscript remains constant, refers to a different date at which the variable was measured. Thus each row contains all available estimates referring to a given time period. For the first time period a full series of estimates from y_1^1 to y_1^v is available, but for the most recent period only one estimate y_t^v is available at the current time. The last data value shown in each column is the first release of variable y. Therefore, moving down the main diagonal (connecting y_1^1, y_{t-l}^{v-l} and y_t^v) collects the initial data release for each reference period.[6]

Figure 2: Real-time data (or revisions triangle)

$$\begin{bmatrix} y_1^1 & \cdots & y_1^{v-l} & \cdots & y_1^v \\ & \ddots & \vdots & & \vdots \\ & & y_{t-l}^{v-l} & \cdots & y_{t-l}^v \\ & & & \ddots & \vdots \\ & & & & y_t^v \end{bmatrix}$$

Source: Jacobs and van Norden (2011)

This study investigates QNA data from the period 2005Q4, first published in April 2006, to 2018Q4 published in March 2019. Data referring to periods prior to 2005Q4 are also avail-

[6]Note that the frequency of data releases does not necessarily correspond to that of observed time periods. For example, quarterly observations could be updated in monthly data releases. In addition, the figure shows that the first available estimates are released without a lag. This assumption can be relaxed so that a typical entry in the main diagonal may be y_j^{j+l} rather than y_j^j where l indicates the lag.

able, but to avoid bias in the results, the revisions triangle has to be symmetric. Therefore observations referring to dates prior to 2005Q4 are ignored.[7] This is important to keep the time lag between the reference quarter and the first estimate constant. In other words, revisions to quarters prior to 2005Q4 are not directly comparable to those for later periods, since more information was already available when the first estimate was released. The resulting dataset comprises 53 quarters and 52 published vintages.[8] As one can deduct from table A1 in the appendix, the number of estimates declines as the reference period moves closer to the present, leading to an unbalanced panel structure. For the first reference period (2005Q4) 52 estimates are available while for the most recent quarter only one observation exists. This leads to a total of 1395 observations. This study focuses not only on GDP but includes the main components of the expenditure approach, namely household consumption, government consumption, gross capital formation (GCF), imports and exports. In addition, it considers total employment (ETO) and compensation to employees.

For the chained volume series, I investigate revisions to the annual growth rates at quarterly frequency. For employment and compensation to employees, obviously , the annual growth rates are calculated for the headcount and the current price series. Since the analysis focuses on year-on-year growth rates, I use the unadjusted data rather than seasonal- or working day-adjusted series. The seasonal- and working day-adjusted series published by STATEC are not suitable for two reasons. First, STATEC only released adjusted series at a later stage, starting in 2008. Second, any changes to the statistical method of seasonal adjustment would increase the complexity of the analysis.[9]

Figure 3 is an illustration of the underlying data. It compares year-on-year real GDP growth according to the first estimate for each quarter to the vintage release in April 2019 ("latest estimate").[10] As the latter is based on all new information available, it is often considered the estimation closest to the "true" value. It is important to stress that the latest estimate may still be subject to large revisions, especially for more recent quarters some of which are early releases. The first estimate corresponds to the main diagonal of the revisions triangle.

[7] The data structure including data prior to 2005Q4 would be shaped as a trapezoid rather than a triangle.

[8] For undisclosed reasons, STATEC did not provide a first estimate of 2014Q4 in April 2015 but only released it in July 2015 with the 2015Q1 estimate.

[9] Note that updating the seasonal adjustment factors with each vintage can cause sizeable revisions to quarterly growth rates even without changes to the underlying unadjusted data or to the statistical method applied.

[10] Figure 4 in section 5.1 plots all available vintages of y-o-y real GDP growth.

Figure 3: First vs. latest estimate of y-o-y real GDP growth
(in percent)

Source: STATEC, own calculations.

Overall, there is relatively strong co-movement between the first and latest estimate of year-on-year real GDP growth. Interestingly, the path of the first estimate seems to be somewhat smoother. Early releases by national accountants tend to underestimate the peaks and bottoms of economic growth. One possible explanation is that early estimates might not be able to anticipate the exact timing of turning points. This can be most clearly seen in the high growth period in 2007 prior to the financial crisis and in the negative growth phase in 2008 and 2009.

4 Methodology

4.1 The revisions and the revision horizons

The real-time data structure allows one to analyse data revisions of specific variables over a given time horizon. Revisions are usually calculated as the later vintage estimate minus an earlier vintage estimate of the same reference period. This would consist in taking the difference between columns of the revision triangle (see figure 2). In this context, a revision r between vintages v and v' (where $v' > v$) is defined as

$$r_t^{v'v} = y_t^{v'} - y_t^v \tag{1}$$

In this study I am most interested in comparing the first release to later releases, e.g. the second release or even estimates released after one or several years. I concentrate on the following revision horizons: (i) first update after one quarter, (ii) one year revision after four quarters, (iii) three year revision, (iv) five year revision and (v) the final revision. The final revision is the difference between the most recent release of a data point and its value when it was first released. The term "final revision", although widely used in the literature, is slightly misleading in the sense that the data under investigation are constantly being revised and thus the "true" or "final" value remains unknown.

4.2 Direction and size of revisions

There are several ways to measure revisions to national accounts. The most commonly used measures are mean revision and mean absolute revision. The primary interest of these measures lies in analysing the sign and the size of revisions and providing an indication of systemic patterns in the revision process.

The mean revision MR is the average of the revisions in the sample period,

$$MR = 1/n \sum_{t=1}^{n} r_t^{v'v} \tag{2}$$

where n is the number of observations. A positive (negative) sign indicates that, on average, earlier releases have been underestimated (overestimated). To get a better notion of the distribution, I report the standard deviations as well as the range for the different revision horizons. The standard deviation measures the spread of revisions around their mean. The range and the standard deviation serve as a measure of uncertainty and hence give an indication of the variability of the revisions.

Ideally, revisions should be random and concentrate around zero. If not, revisions become theoretically predictable by adjusting the early estimate for the observed non-zero bias. Therefore it is important to test whether mean revisions are statistically different from zero, i.e. consistently positive or negative and hence biased. Following the literature, I use a simple and robust approach based on the Heteroskedasticity Autocorrelation Consistent (HAC) variance estimator proposed by Newey-West (1987) to evaluate the statistical significance of MR.

In the mean revision MR measure, large revisions of opposite sign compensate each other. As a result, it is also useful to look at the mean absolute revision MAR, which is the average of the absolute value of the revisions in the sample period,

$$MAR = 1/n \sum_{t=1}^{n} \mid r_t^{v'v} \mid \tag{3}$$

The mean absolute revision tests for reliability based on the dispersion of revisions. Large revisions (irrespective of sign) increase the MAR. So, even without a significant bias in the mean revision MR, a large MAR indicates a high uncertainty surrounding the estimates.

To complement the analysis on mean revisions, the relative mean absolute revision $RMAR$ corrects the MAR for the size of the estimated value. It takes into account the fact that revisions might be expected to be more sizeable when the estimated value is large. The $RMAR$ is defined as follows,

$$RMAR = \frac{\sum_{t=1}^{n} \mid r_t^{v'v} \mid}{\sum_{t=1}^{n} \mid y_t^{v'} \mid} \tag{4}$$

It is important that first releases accurately reflect the state of an economy. If revisions subsequently change the direction of growth, early estimates tend to be less useful. The accuracy of these signals can be assessed by counting the occurrences where the sign of year-on-year

growth from the early estimates changes in later vintages. This is fulfilled when either condition is satisfied,

$$\begin{aligned} \Delta y_t^v \succ 0 \quad \text{and} \quad \Delta y_t^{v'} \prec 0 \\ \text{or} \\ \Delta y_t^v \prec 0 \quad \text{and} \quad \Delta y_t^{v'} \succ 0 \end{aligned} \tag{5}$$

Similarly, one can count how often acceleration/deceleration of the year-on-year growth rate changes over the revision process. Formally, this is verified when either condition is met,

$$\begin{aligned} \Delta\Delta y_t^v \succ 0 \quad \text{and} \quad \Delta\Delta y_t^{v'} \prec 0 \\ \text{or} \\ \Delta\Delta y_t^v \prec 0 \quad \text{and} \quad \Delta\Delta y_t^{v'} \succ 0 \end{aligned} \tag{6}$$

Finally, I examine how revisions in overall GDP are related to revisions in its expenditure components. For this purpose, I calculate contributions to real GDP growth rate revisions using the relative share (expressed in current prices) for each component. I will focus on the latest vintage in April 2019 (release of 2018Q4) relative to the first estimate.

4.3 News vs. Noise

The "news vs. noise" analysis, first introduced by Mankiw et al. (1984) and Mankiw and Shapiro (1986), can be used to give further insights into the efficiency of preliminary estimates. Ideally, revisions should represent *news*, i.e. incorporate more accurate and detailed information which become available after the earlier release. In contrast, revisions may contain *noise* when the change in the estimate is due to systematic measurement errors (or bias). The existence of *noise* indicates that a more efficient estimate would have been possible given the information set at the time and that (in theory) the bias could be exploited to forecast future revisions. If revisions only contain *news*, they should be independent of earlier estimates and hence unpredictable. Statistical tests can be applied to distinguish between the *news* and *noise* hypothesis.

More formally, the final or "true" value of a variable can be expressed as follows,

$$y_t^* = y_t^v + e_t \tag{7}$$

The true value y_t^* equals the data release y_t^v for the period t at vintage time v plus an error term e_t. Under the *news* hypothesis, the error term is orthogonal, i.e. independent of y_t^v. If the error term e_t contains a systematic measurement bias, e_t is correlated with the preliminary release. The final revision would be predictable and the initial release will not be an optimal forecast of the "true" value. I apply the regression technique presented in Faust et al. (2005) and McKenzie et al. (2008) to identify *news* and *noise* in revisions. This method mainly consists in a forecast efficiency test, also known as the Mincer-Zarnowitz test (see Mincer and Zarnowitz (1969)). To test the predictability of revisions, one can run the regression,

$$r_t^{v'v} = \alpha + \beta y_t^v + u_t \tag{8}$$

and test whether $\alpha = \beta = 0$. If the parameters are found to be significantly different from zero, one would conclude that the revisions contain *noise* because they depend on the preliminary estimate. In this case one could technically use the regression to predict future revisions. The standard errors are computed by correcting for heteroscedasticity and for serial correlation using the Newey-West (1987) approach.

5 Empirical results

5.1 Graphical analysis

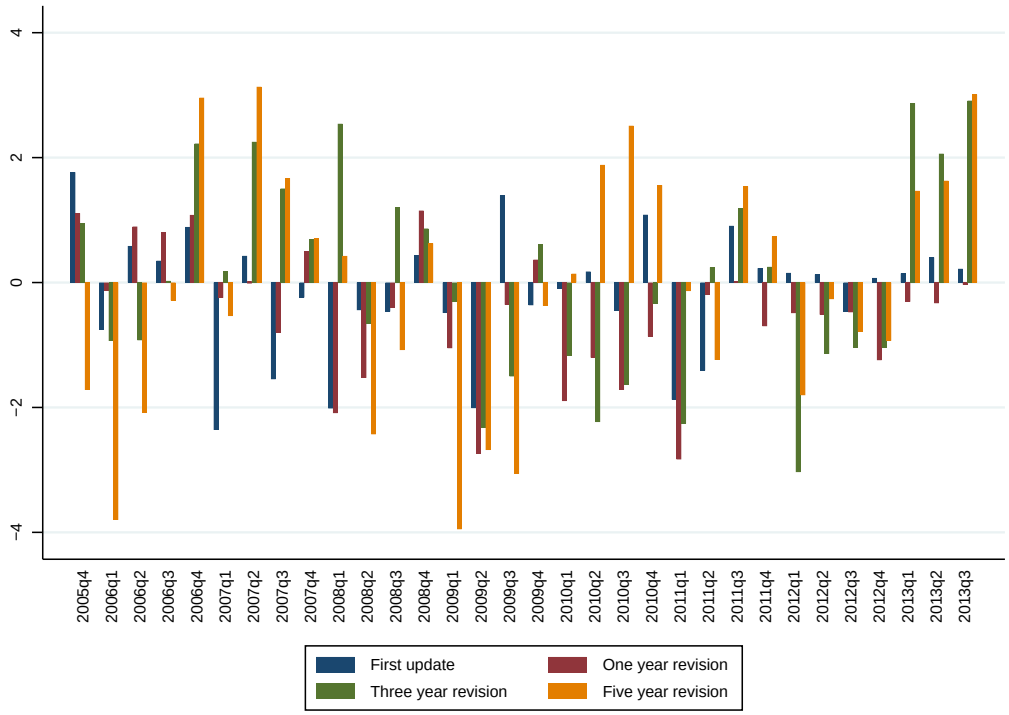
Figure 4: Vintages of y-o-y real GDP growth
(in percent)

Source: STATEC, own calculations.

Figure 4 plots all available vintages of yearly GDP growth to gain an overall impression of the uncertainty surrounding GDP estimates. The corresponding figures for the main components can be found in the annex (see A1 and A2). The vintages of year-on-year real GDP growth show a relatively strong co-movement, however with a sizeable dispersion. The difference between the lowest and the highest estimate for a particular quarter can exceed five percentage points. The same holds true for some of the main GDP components, namely gross capital formation, exports and imports, in some cases with even higher ranges. Strong co-movement between vintages is also confirmed for compensation to employees and total employment. Household

and government consumption are characterised by lower correlation across vintages.

Figure 5: Revisions to y-o-y real GDP growth
(in percentage points)



Source: STATEC data, own calculations.

Figure 5 shows the revisions to year-on-year real GDP growth for each quarter at the selected revision horizons: (i) first update after one quarter, (ii) one year revision, (iii) three year revision and (iv) five year revision. Five year revisions can only be observed for 2013 and previous years.

It can be seen that revisions differ with the time spans. Sizeable revisions even occur after one or several years. For a specific quarter, revisions across different releases can be positive or negative and hence can offset each other. For instance, real GDP growth in 2005Q4 was revised upwards in the first update. However this was more than offset by subsequent downward revisions, leading to an overall downward revision after five years. The figure also shows that there are no distinct outliers over the observation period (e.g. during the financial crisis in 2008 and 2009).

Overall, revisions after a given number of releases might be small even if large positive and negative revisions occurred since the first release. Frequent and sizeable changes between vintages increase the uncertainty (and reduce the utility) of the QNA data. Given the relatively small observation period, it is difficult to assess whether revisions have become smaller.

5.2 Direction and size of revisions

In this section, I apply several statistical measures as described in section 4. The primary interest of these measures lies in analysing the sign and size of data revisions and to test whether a systematic pattern emerges. Table 1 shows the mean revision MR, the standard deviation STD, the range, the mean absolute revision MAR (all expressed in percentage points) and the relative mean absolute revisions $RMAR$ for the year-on-year growth rates of GDP and its main components (expressed in percent). An MR significantly different from zero (denoted with *) indicates a bias in the revision process. I apply Newey-West corrected standard errors with a significance level of 5 %.

The reliability of these estimates can also be assessed by looking at changes in the direction of growth over the revision process. The column labelled "Sign" in table 1 shows the percentage of quarters where the revised estimates have a different sign compared to the initial release. Similarly, the final column labelled "Acc./Dec." indicates the share of quarters in which an acceleration in the first release switched to a deceleration (or vice-versa) in the later release.

The first section of table 1 presents the revisions to year-on-year real GDP growth rates for several revision intervals. At first sight, the results for MR show a rather satisfying picture. The MR for all revision intervals are relatively small, ranging from -0.6 % to 0.1 %. Only the MR after one year shows a significant negative result (-0.6 %) which means that the first estimate of year-on-year real GDP growth tends to be significantly revised down after one year. This can partly be explained by the fact that after one year the first estimate of the annual national accounts (ANA) becomes available. The QNA is usually benchmarked to fit the ANA, which is based on a more complete and better quality information as well as a deeper analysis of the compilation process. Despite the relatively favourable assessment drawn from the MR, the results clearly point to high variability in revisions. For instance, revisions after three years show a MR of 0.1 %. However, the standard deviation of 1.7 % reveals that data points tend to be relatively far away from the mean. Columns 5 and 6 indicate that revisions after three years

Table 1: Revisions to y-o-y real growth of GDP and main components at quarterly frequency, 2005-2018

Variable	Revision interval	MR	STD	Range		MAR	RMAR	Sign	Acc./Dec.
				Min	Max				
GDP	First update	−0,1	1,1	−2,4	3,2	0,8	38%	2%	21%
	One year later	−0,6*	1,2	−4,0	1,8	1,0	135%	–	29%
	Three years later	0,1	1,7	−3,1	3,0	1,4	50%	5%	27%
	Five years later	−0,1	2,0	−4,0	3,1	1,6	66%	–	31%
	Final revision	−0,3	1,9	−4,5	4,9	1,5	57%	4%	28%
Household consumption	First update	0,3*	0,9	−1,4	3,4	0,7	95%	6%	25%
	One year later	0,5*	1,4	−4,0	2,9	1,2	81%	12%	31%
	Three years later	0,8*	1,8	−1,9	5,3	1,5	73%	15%	34%
	Five years later	0,6	1,7	−3,0	3,5	1,4	302%	22%	31%
	Final revision	0,8*	1,6	−2,8	4,8	1,4	108%	17%	36%
Government consumption	First update	0,6*	1,6	−4,0	5,9	1,2	60%	4%	31%
	One year later	1,6*	2,8	−2,6	14,9	2,2	69%	8%	55%
	Three years later	0,8*	2,0	−3,7	5,7	1,7	90%	10%	49%
	Five years later	0,9	2,2	−3,7	6,5	1,9	883%	13%	41%
	Final revision	0,5	1,6	−3,4	4,3	1,3	177%	8%	51%
Gross capital formation	First update	−0,0	6,6	−22,5	14,8	4,6	514%	10%	4%
	One year later	0,8	8,8	−18,1	21,2	6,8	227%	18%	8%
	Three years later	2,2	12,7	−19,9	33,0	10,0	2467%	20%	5%
	Five years later	0,5	9,7	−24,4	15,8	8,0	185%	28%	9%
	Final revision	2,7	11,3	−24,4	25,4	9,4	402%	28%	11%
Exports	First update	−0,1	1,4	−3,0	2,8	1,1	34%	2%	12%
	One year later	−0,5	3,4	−8,5	9,9	2,6	124%	8%	27%
	Three years later	1,8*	3,8	−4,9	11,8	3,4	91%	12%	22%
	Five years later	0,8	4,0	−7,8	8,4	3,4	98%	22%	22%
	Final revision	1,1	4,8	−8,5	14,5	3,8	77%	19%	23%
Imports	First update	0,1	1,6	−3,4	3,6	1,3	1452%	2%	17%
	One year later	0,2	3,8	−7,2	12,4	3,0	149%	6%	20%
	Three years later	2,6*	4,4	−5,3	12,3	4,2	138%	10%	17%
	Five years later	1,4	4,6	−7,1	10,6	4,0	86%	13%	22%
	Final revision	2,0*	6,0	−7,2	17,5	4,7	85%	13%	25%
Total employment	First update	0,0	0,1	−0,3	0,4	0,1	5%	–	10%
	One year later	0,1*	0,1	−0,2	0,4	0,1	7%	–	8%
	Three years later	0,1*	0,1	−0,1	0,6	0,2	8,2%	–	–
	Five years later	0,2*	0,2	−0,2	0,6	0,2	10%	–	–
	Final revision	0,1*	0,1	−0,1	0,6	0,1	10%	–	6%
Comp. to employees	First update	0,1	0,5	−0,8	1,9	0,4	10%	–	8%
	One year later	0,8*	0,8	−0,7	2,9	0,8	16%	–	16%
	Three years later	0,5*	0,8	−0,7	2,3	0,7	16%	–	12%
	Five years later	0,4*	0,9	−0,8	2,7	0,8	17%	–	16%
	Final revision	0,7*	0,9	−1,2	2,7	0,9	16%	–	15%

Mean revisions (MR), Standard Deviations (STD), Range and Absolute Revisions (MAR) in percentage points. Relative MAR (RMAR), Sign and Acc./Dec. in percent. Mean revisions with * are significantly different from zero at 5% level.
Source: STATEC, own calculations.

have ranged between -3.1 % and 3.0 %.

The MAR, 1.6 % after three years, indicates that revisions are quite large in absolute value and correspond to 50 % of the initial estimate ($RMAR$). The same holds true for revisions at other horizons. One can also see that the MAR tends to increase at longer horizons, which indicates that important information may only become available after several years. The sign of the initial release is usually not revised. This is not surprising as the economy grew above 2.5 % on average since 2006 with negative growth only observed during the financial crisis (2008 and 2009) and 2012. In fact all revisions in the sign of real GDP growth are related to the financial crisis and the later recovery. Considering accelerations/decelerations, the QNA display a less reliable picture. In around 25 % of cases, acceleration/deceleration switches compared to the initial release. All things considered, year-on-year GDP growth rates face relatively large revisions which indicates high uncertainty surrounding the estimates.

Except for gross capital formation (GCF), results in table 1 point to a positive bias in the main components. The year-on-year growth rates of household and government consumption are significantly revised upwards in later releases. Exports and imports show sizeable and significant revisions after three years, although not at shorter horizons. This suggests that relevant information only becomes available with a lag. As imports and exports are both revised up, the impact on the net exports and ultimately on GDP is unclear. The variability in revisions is quite high for all the components. However the MAR, the standard deviation and the range indicate that revisions in GCF tend to be more sizeable than for other components. No clear pattern emerges from the last two columns of table 1. Imports and exports appear to be more reliable than domestic demand components.

Growth in compensation to employees and in total employment faces significant positive revisions, even after five years. The $RMAR$ however indicate that these revisions are less sizeable compared to those in GDP components. As both series grew continuously since the QNA were first released, there are no instances of a revision to the sign of growth. Initial releases of total employment growth tend to be highly reliable in the final column.

Since the introduction of the QNA in 2006, one major statistical benchmark revision took place with the implementation of ESA 2010 in September/October 2014 (see section 3.1). To check whether the results reported in table 1 could be primarily driven by this benchmark revision, I fully neutralised the revisions for this particular vintage setting them all to zero. This

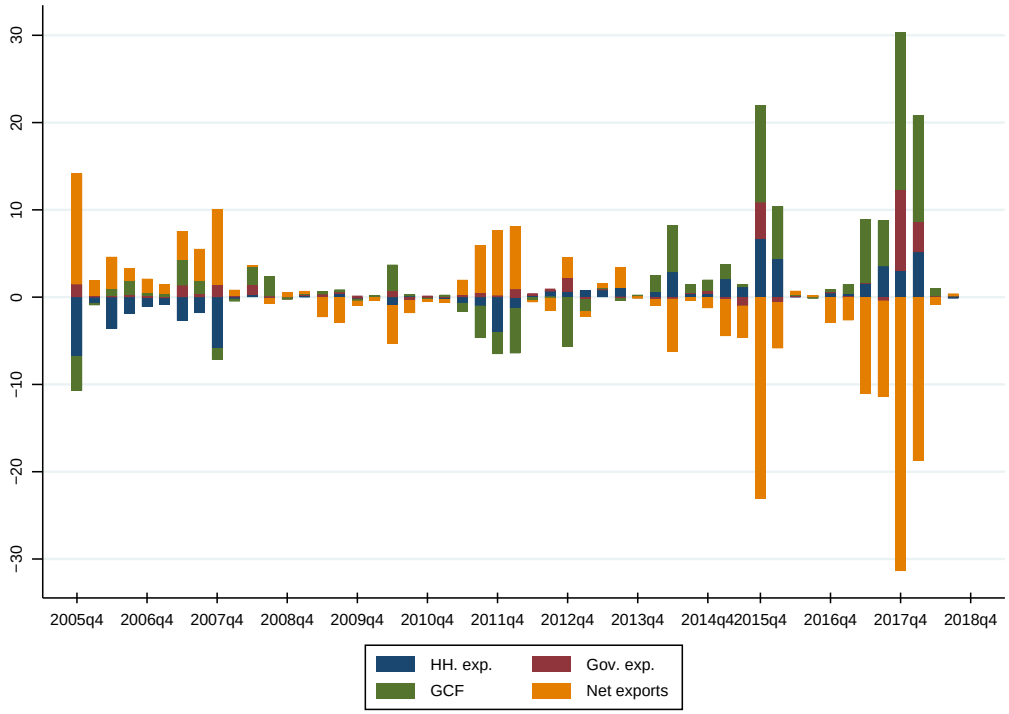
represents a rather cautious approach, since revisions might reflect new information in addition to the benchmark revisions. In other words, this approach tends to overestimate the revisions stemming from the implementation of ESA 2010 and underestimate those from different origins. This robustness check confirms that results are not primarily driven by the methodological changes in 2014. The same conclusion holds true for real GDP and the domestic demand components. For exports and imports however, the significance level of the MR after three years becomes borderline significant at the 10 % level. This suggests that the implementation of ESA 2010 may have contributed to the revision bias observed in the trade components.

5.3 Contributions to revisions

In this section, I document how revisions in overall GDP growth are related to revisions in its expenditure components. Figure 6 depicts the accounting contributions of GDP expenditure components to revisions in year-on-year real GDP growth. For instance, the overall positive revision of real GDP growth in 2005Q4 is mainly associated to an upward revision in net exports. However this positive revision is partly offset by a negative revision in household expenditure and gross capital formation. Revisions in government expenditure only play a minor role in overall GDP revisions.

Luxembourg's GDP estimates are mainly based on the production approach. The expenditure approach, although partly based on data and methods distinct from those used for the production approach, is not fully independent. In other words, some of the expenditure components are calculated as a residual. This means that the causality from revisions in GDP expenditure components to revisions in overall GDP is not straightforward. This section should rather help to better understand reliability of the main GDP expenditure components.

Figure 6: Contributions to y-o-y real GDP growth rate revisions
(in percentage points)



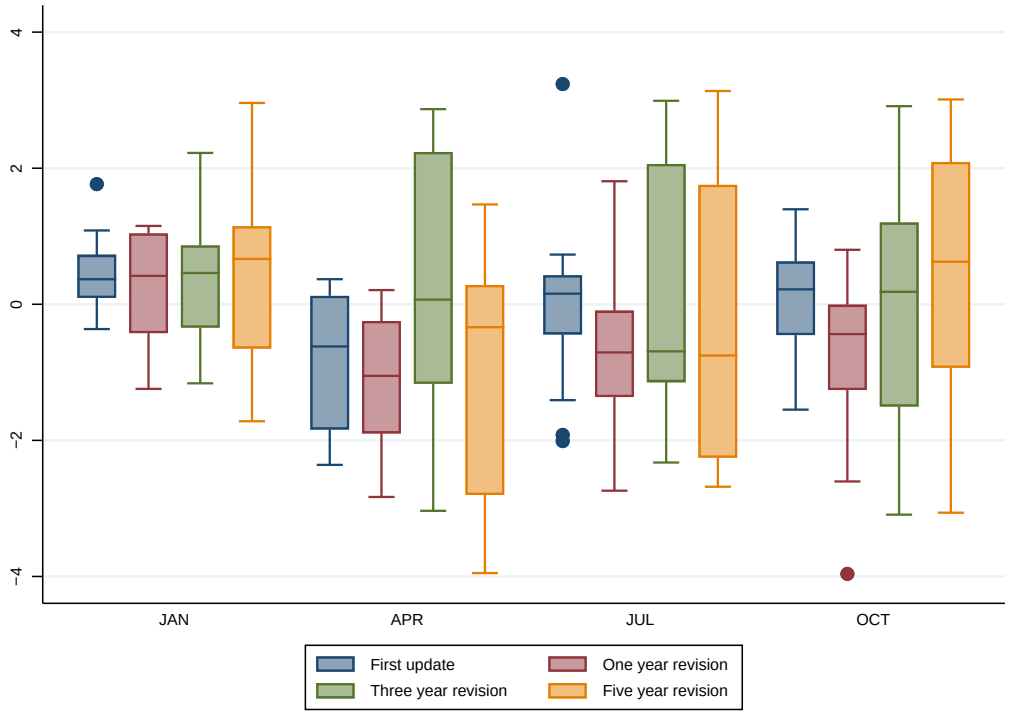
Note: Revisions are based on the first estimate relative to the latest vintage (April 2019).

Source: STATEC, own calculations.

More generally, revisions in net exports seem to play a dominant role in GDP revisions. This can mainly be attributed to the fact that (i) net exports represent the largest share of nominal GDP in levels (about one third) and (ii), as shown above, exports and imports are subject to significant revisions, especially after three years. Revisions in household consumption and gross capital formation, with average shares in nominal GDP of 32 % and 19 %, are also strongly related to GDP revisions, whereas revisions in government consumption only play a minor role. It also appears that revisions to different components often offset each other, which dampens the overall impact on real GDP growth. This suggests that revisions could be due to reclassification from one component to another. None of the components systemically contributes more positively or negatively to revisions in real GDP growth.

5.4 Revisions and the release dates of national accounts

Figure 7: Revisions to y-o-y real GDP growth by release dates
(in percentage points)



Note: Whiskers show the upper and lower adjacent value and dots represent outliers.

Source: STATEC, own calculations.

An accurate estimate of national accounts depends crucially on the information available at the time of estimation. It is therefore interesting to investigate whether revisions are dependent on the calendar month of the release as STATEC collects more information over the year. The QNA are published four times a year, usually in January (Q3 release), April (Q4 release), July (Q1 release) and October (Q2 release). Figure 7 depicts the revisions to year-on-year real GDP growth at selected revision horizons for the four release dates. The corresponding figures for other variables can be found in the annex (see A3 and A4). The results have to interpreted with caution as the number of observations is relatively low, especially for the longer revision horizons. For instance, only eight observations per release are available for the five year revision horizon.

The size, and in some cases the direction, of revisions vary across the release dates. The revision of year-on-year real GDP growth rates from the January release are relatively small and usually positive compared to revisions of the April and July releases which tend to be negative and more sizeable. A possible explanation for these discrepancies lies in the compilation process of national accounts. The annual national accounts (ANA), usually released in October, is the most reliable and comprehensive exercise to estimate Luxembourg's national accounts (see figure 1 in section 3.1). It follows that the QNA are generally subject to major revisions once the ANA are published. The estimation of Q2 in October and Q3 in January relies on more timely and reliable ANA figures for the previous year. The compilation of Q3 in April and Q1 in July can only rely on QNA estimates of the preceding year as annual data are not yet available. The results also indicate that QNA estimates in April and July tend to be overly optimistic and need to be revised down once the more reliable annual figures are available.

For household and government consumption, figure A3 in the appendix confirms the findings presented above. The overall positive and significant mean revisions seem to hold for most publication dates. This conclusion also holds for total employment and compensation to employees (see figure A4). The growth rates of GCF tend to be positively revised when released in July and negatively in April. For exports and imports, no clear pattern emerges. The large and substantial revisions after three years are however confirmed and seem to be unrelated to the release date.

5.5 News vs. Noise

In this section I apply the "news vs. noise" framework described in section 4.3. The objective is to test whether revisions to national accounts are statistically independent of the level of the first release. If so, the interpretation is that revisions occurred due to the arrival of *news* and the revised data incorporate information which has become available only after the first estimate. If not, revisions contain a predictable element or significant bias (*noise*).

Table 2 summarises the regression results based on the forecast efficiency test of Mincer and Zarnowitz (see equation 8 in section 4.3). Revisions to the growth rate for a given component are regressed on first estimates including a constant. In this setup, the regression is based on the 1-year revision. To test for the joint hypothesis that the constant and the coefficient are both zero, the F-statistic is presented (significant results are printed in bold). Table A2

in the appendix shows the results for three year and five year revisions. Given the relatively low number of observations, the results have to interpreted with caution. The standard errors are computed correcting for heteroscedasticity and for serial correlation using the Newey-West (1987) approach.

Table 2: News vs. Noise: Regression analysis I

	1-year revision			
Variable	**Intercept**	**Coeff.**	**F-Stat**	**Prob.**
GDP	-0,0057***	0,0031	0,00	0,96
	(0,0017)	(0,0629)		
Household consumption	0,0081**	-0,2577	2,01	0,16
	(0,0033)	(0,1816)		
Government consumption	0,0278***	-0,6056***	**15,75**	**0,00**
	(0,0035)	(0,1526)		
Gross capital formation	0,0136	-0,1633**	**4,35**	**0,04**
	(0,0139)	(0,0783)		
Exports	0,0001	-0,1228	1,60	0,21
	(0,0067)	(0,0971)		
Imports	0,0053	-0,0929	1,09	0,30
	(0,0076)	(0,0890)		

Notes: Standard errors in parentheses; $^{*}p \leq 0.1$, $^{**}p \leq 0.05$, $^{***}p \leq 0.01$. Sample of 49 obs. F-Statistics apply heteroscedasticity and autocorrelation-robust Wald tests (Newey-West estimator). F-Statistics printed in bold are significant at a 10% level.

Results suggest that revisions to the real GDP growth rate do not appear to contain a significant bias. This is also supported by the results shown in table A2 in the appendix. The F-test is not significant for any of the different horizons. However, this conclusion does not hold for all the expenditure components. Government consumption and gross capital formation show significant F-statistics. The joint hypothesis that the constant and the coefficient are both zero is rejected at least at a 5 % significance level. Government consumption shows similar results for three year and five year revisions. These results indicate the existence of significant bias for these components. The initial estimates themselves could thus be used to predict revisions. The revisions seem to contain *noise* and consequently a more efficient estimate for the first release would have been possible. Finally, the regression results do not find any evidence of bias in imports and exports data.

6 International comparison

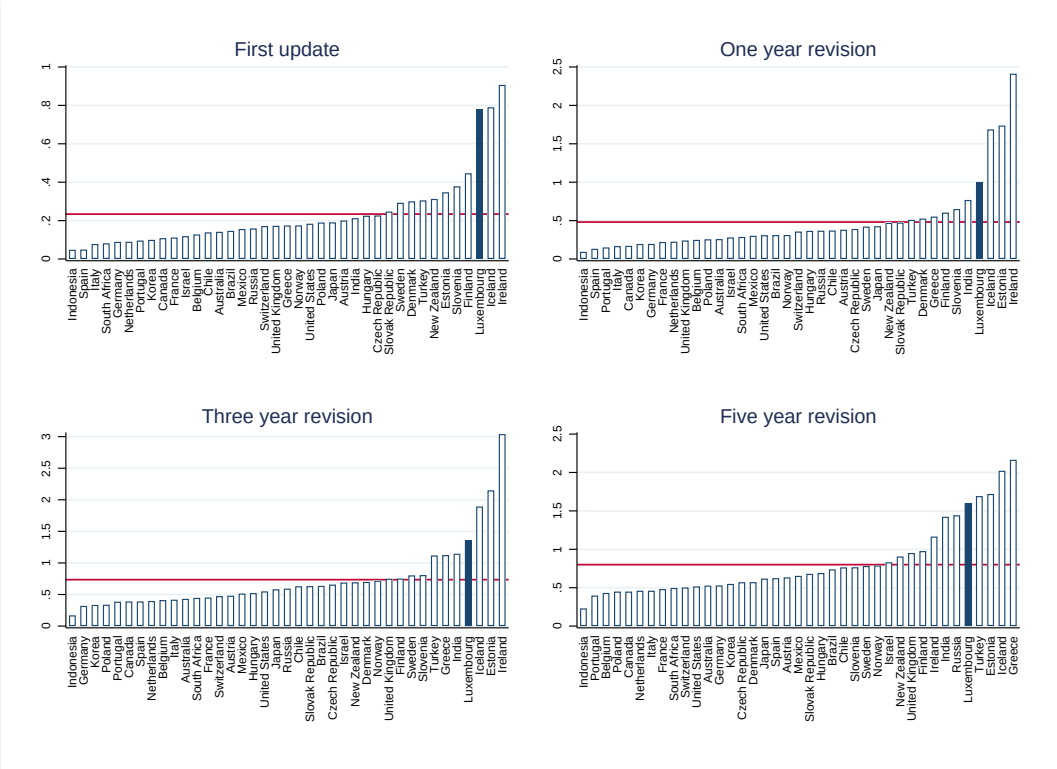
To put the revisions to Luxembourg's QNA in perspective, I compare the results from Luxembourg with other OECD countries using the OECD real-time database. I calculate revisions at the selected revision horizons for all OECD countries using the same sample period (2005Q4 to 2017Q4) to allow for a consistent comparison. The OECD real-time database only provides seasonally adjusted data which, in theory, should not lead to significant differences when analysing year-on-year growth rates. Neumayr (2010) however finds inconsistencies related to seasonal adjustments in the OECD database for some of the Luxembourg data. Indeed, there are some discrepancies between the QNA data published by STATEC and the series reported in the OECD database. However this disparity only results in minor differences when computing revisions to year-on-year growth rates. For Luxembourg, I use the statistics presented above to be consistent throughout the analysis.

6.1 Size of revisions

Figure 8 compares the mean absolute revision to year-on-year real GDP growth across OECD countries. For all selected revision horizons, Luxembourg's MAR clearly lies above the OECD average (red line). Together with Ireland, Estonia and Iceland, Luxembourg ranks among the countries with the highest mean revisions in absolute value.[11]

[11] Despite a different sample period, results here are broadly in line with the most recent analysis published by the OECD (see Zwijnenburg (2015)).

Figure 8: MAR of y-o-y real GDP growth for OECD countries
(in percentage points)



Source: OECD, STATEC and own calculations.

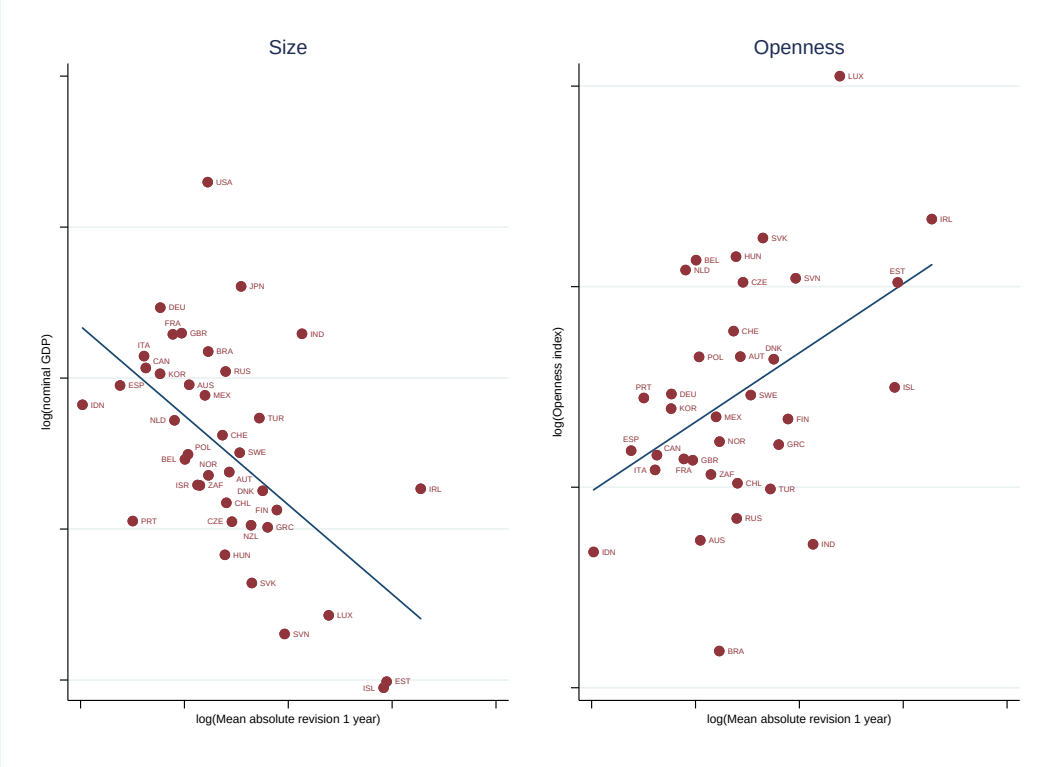
Countries with high MAR share some common features, including small size and considerable openness of their economies, which might explain the more sizeable revisions relative to other OECD countries. Very small and open economies tend to be more dependent on developments in particular economic sectors or even on specific firms, are more vulnerable to external shocks and may be characterised by more volatile business cycles. These factors create some difficulties to measure output accurately, especially in early releases with only limited information is available.

Figure 9 indicates the relationship between the size or the openness of an economy and the mean absolute revision to GDP.[12] Indeed, one can see a negative correlation between the size of an economy (measured in terms of 2017 nominal GDP) and the MAR for revisions after one year.

[12]For illustration purposes, all variables are logged.

The relationship between the openness index (the sum of exports and imports measured as a share of GDP) and the MAR is positive, but somewhat weaker. For instance, some open economies (like Belgium and the Netherlands) feature relatively small revisions to real GDP growth. Such one-dimensional analyses are not sufficient to explain the dispersion of revisions, however they can give some indication of the relevant factors. Using a similar dataset, Casey and Smyth (2016) analyse several factors that may explain cross-country differences in revisions. The authors observe similar relationships between the size of revisions and the size and openness of an economy; however they cannot exclude that their findings are driven by outliers from Ireland and Luxembourg.

Figure 9: Size and openness of the economy compared to MAR of real GDP growth

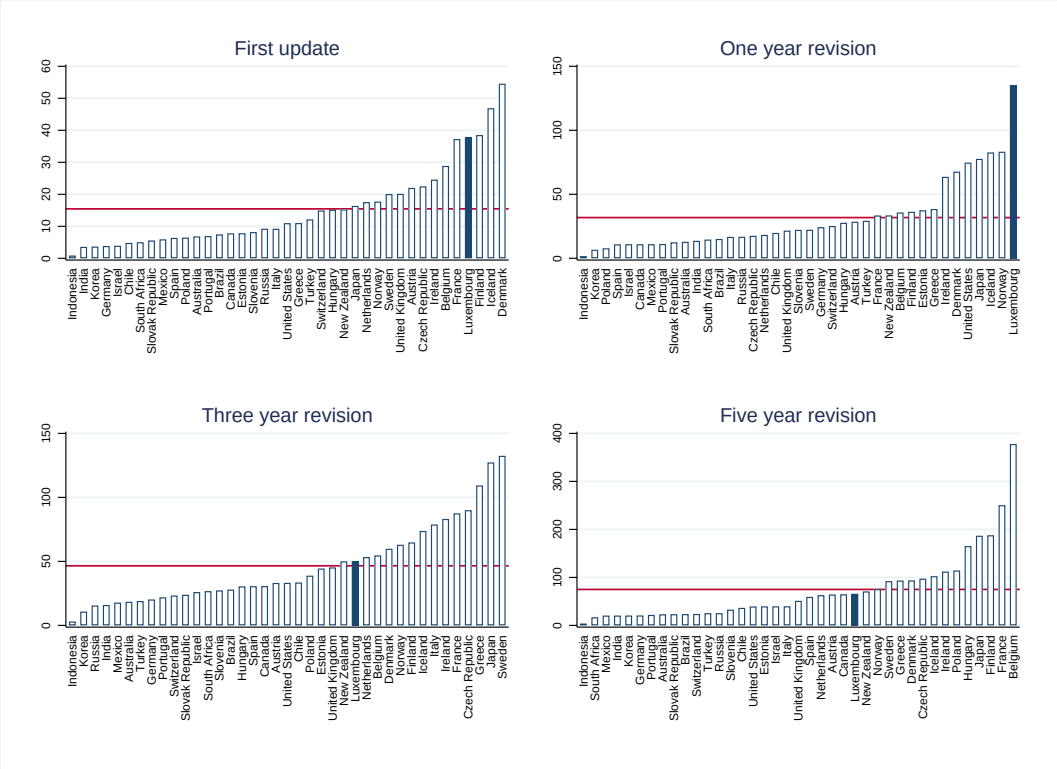


Source: OECD, STATEC, World Bank and own calculations.

To complement the comparison on absolute revisions across countries, it is also useful to look at the relative mean absolute revision. The $RMAR$ has the advantage that it considers the size of the initial estimate. Put differently, this metric allows for larger absolute revisions if a

country's average real GDP growth is relatively high. For short horizons, figure 10 confirms the high uncertainty surrounding Luxembourg's early QNA estimates. However for the longer revision horizons, Luxembourg lies close to the OECD average. In contrast to the MAR, some larger economies, like France or Japan, are also prone to relatively large revisions in their early estimates.

Figure 10: $RMAR$ of y-o-y real GDP growth for OECD countries
(in percent)



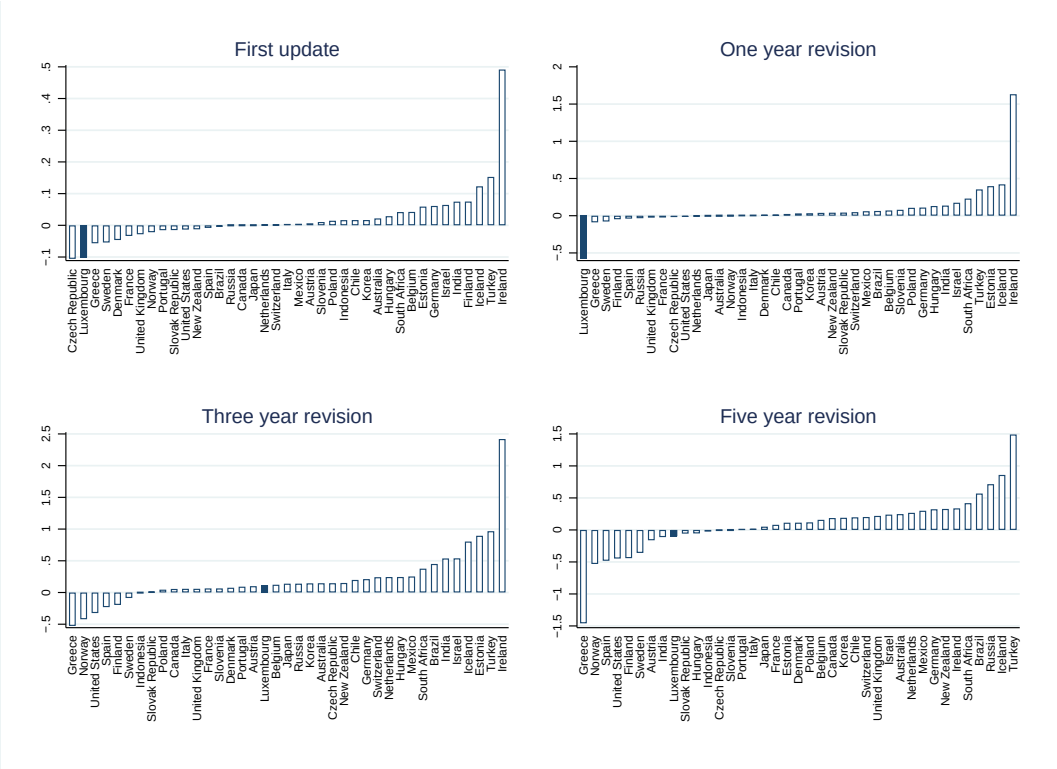
Source: OECD, STATEC and own calculations.

6.2 Direction of revisions

In addition to the absolute size of revisions, one can use the mean revision (MR) to compare Luxembourg's performance in terms of directional unbiasedness. Figure 11 shows the mean revision to year-on-year real GDP growth across the OECD countries. With the exception of the first update, the share of countries that display upward revisions exceeds the share of those

that feature downward revisions. The OECD average is positive for all revision horizons, but not significantly different from zero. Interestingly, Luxembourg ranks among the countries with negative revisions, except for the three year revision horizon. Especially for short horzions, the downward revisions seem to be relatively strong. However, for Luxembourg only the MR relative to the one year horizon is significantly negative.

Figure 11: Mean revisions of y-o-y real GDP growth for OECD countries
(in percentage points)

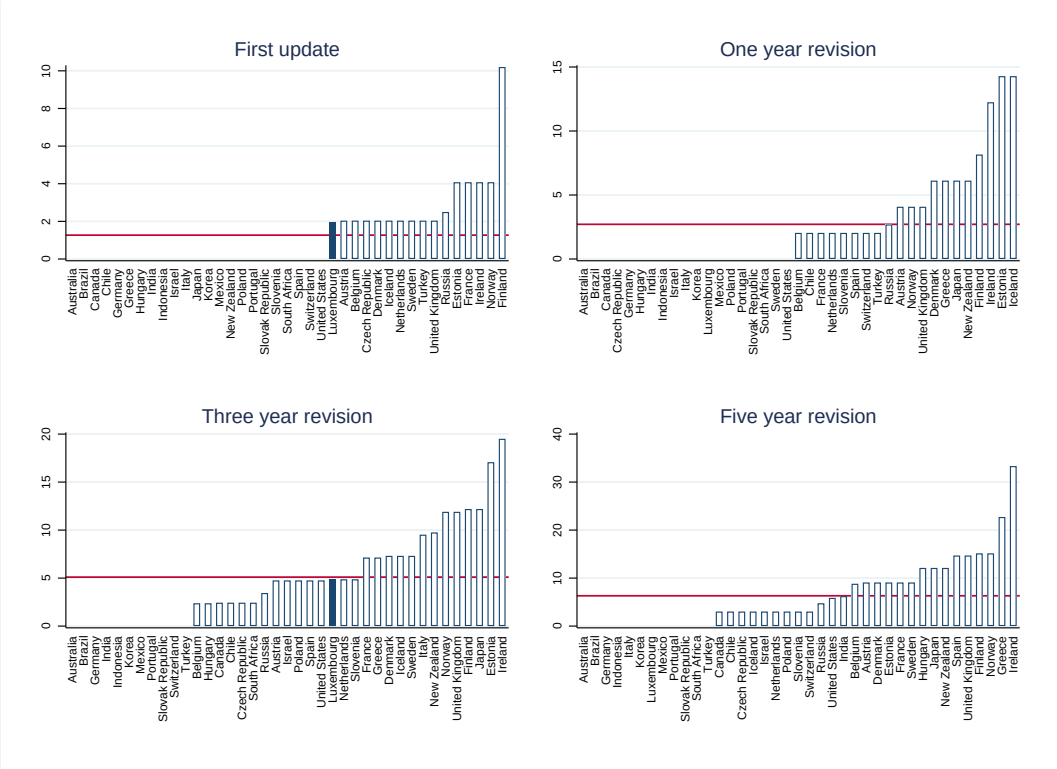


Source: OECD, STATEC and own calculations

Finally, one can investigate the revisions in the sign and accelerations/decelerations for real GDP growth.

In most OECD countries, the sign of the initial release is usually not revised. Across all OECD countries, the sign changes in less than 5 % of subsequent revisions. This is in line with the results for Luxembourg (see figure 12).

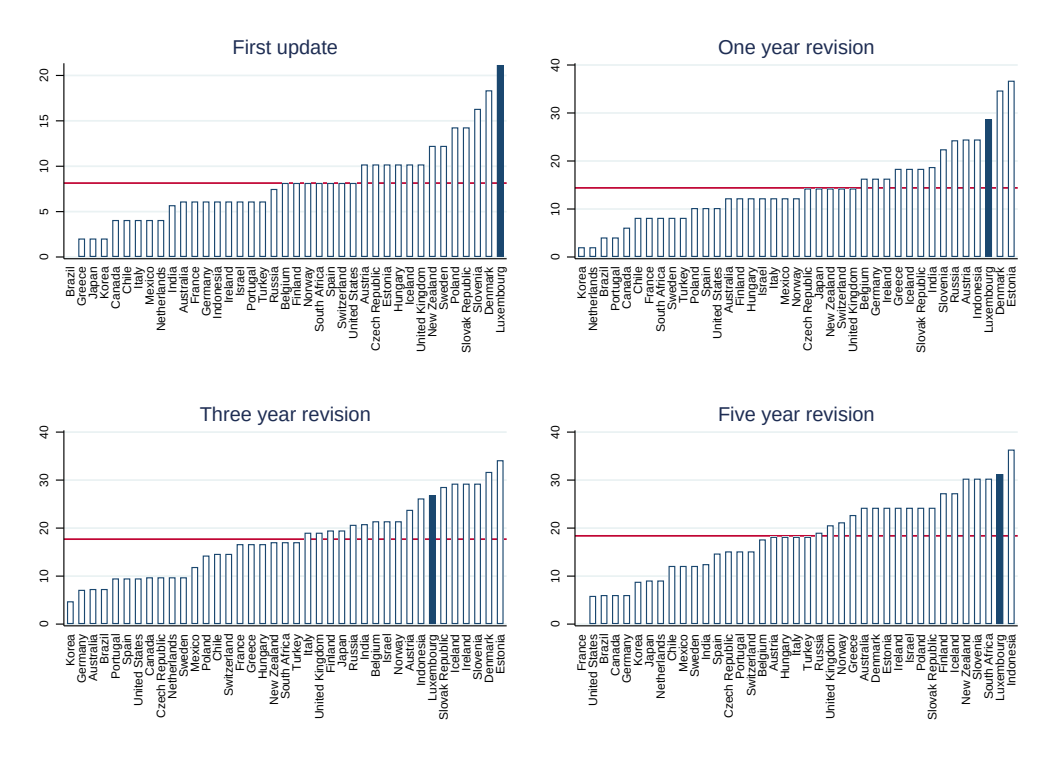
Figure 12: Change in the sign of y-o-y real GDP growth for OECD countries
(in percent)



Source: OECD, STATEC and own calculations

Figure 13 indicates the percent of cases (expressed in percent) where acceleration switched to deceleration or vice-versa. The OECD average is 9 % for the first update and 18 % after five years. For all revision horizons considered, Luxembourg ranks among the countries with the highest share of switches. This is especially true for longer revision horizons, where Luxembourg ranks first and accelerations switch to deceleration (or vice-versa) in 23 % of quarters.

Figure 13: Switches in acc./dec. of y-o-y real GDP growth for OECD countries
(in percent)



Source: OECD, STATEC and own calculations

6.3 Results

Overall, Luxembourg's early QNA estimates are highly uncertain. To some extent this is due to the characteristics of Luxembourg's economy; a very small open economy with a sizeable financial sector. In addition, the presence of large multinational enterprises (MNEs) poses a challenge to the compilation of national accounts data under the SNA/ESA framework (see for instance Tissot (2016)) and may lead to sizeable revisions once more information becomes available. In a recent report, the *Conseil Economique et Social* (CES) highlights these challenges for a highly specialized economy like Luxembourg (see CES (2019)).

Another factor could be that Luxembourg began producing QNA data only a short time ago, in contrast to other OECD countries. The implementation of new statistics often requires

a period for the compilation process to stabilise due to adjustments in methodology and the collection of information. Compared to other countries, this start-up phase might still be over-represented in the Luxembourg data and may thus still affect the comparison.

7 Conclusion

Revisions to Luxembourg's GDP and its components are found to be substantial. While there is no clear evidence of a significant bias in year-on-year real GDP growth rates, this does not hold for some of the GDP expenditure components. Year-on-year growth rates of household and government consumption are significantly revised upwards with later releases. Also growth in imports and exports are subject to significant positive revisions after three years. Similarly, growth in compensation to employees and employment is systematically revised upwards in later releases. The "news vs. noise" framework confirms these findings. Revisions to year-on-year GDP growth rates do not reveal a predictable bias, but the results show a significant bias for several expenditure components, indicating the existence of *noise*. It seems that STATEC systematically underestimates some factors which need to be corrected once more detailed information becomes available. The existence of relatively sizeable revisions also casts doubt on the reliability of initial and recent QNA releases. The sign and acceleration/deceleration appear to be more reliable, although some uncertainty was apparent during the financial crisis. Finally, results show that the reliability also depends on the calendar month of release, suggesting that the availability of new information plays a crucial role in revisions to Luxembourg's national accounts.

Compared to the paper by Neumayr (2010), this study uses a more suitable real-time database and has a longer sample period to analyse revisions in Luxembourg's QNA. The results are not directly comparable, since Neumayr (2010) mainly focuses on quarter-on-quarter real GDP growth rates. This analysis confirms Neumayr's findings that revisions to early estimates tend to increase over time. Also, downward revisions especially over short horizons are present even with the longer sample now. Finally, the conclusion that the sign of growth in the first release is usually not revised in subsequent vintages is confirmed by this study. Nevertheless, in an OECD comparison I find that Luxembourg's early QNA estimates are relatively uncertain. Luxembourg is an outlier in terms of revisions to national accounts data. This is consistent with results in Casey and Smyth (2016).

However, results here need to be treated with caution for several reasons. The history of Luxembourg's QNA is relatively young, dating back only to 2006. It follows that the number of observations in the analysis is still relatively low. STATEC stresses that the annual national accounts are more reliable. The QNA are usually fitted to the ANA. In addition, Luxembourg is a very small open economy and strongly dependent on a relatively volatile financial sector. The presence of multinational enterprises further complicates the compilation process. This study confirms net exports are often subject to significant revisions even after several years. This could explain revisions to overall GDP.

It is crucial that economic analysts and policymakers are aware of the uncertainty surrounding early releases. However, these releases also contain useful information. Further analysis of the revision process is necessary, especially with more observations becoming available, to provide useful insights to compilers and users of national accounts data.

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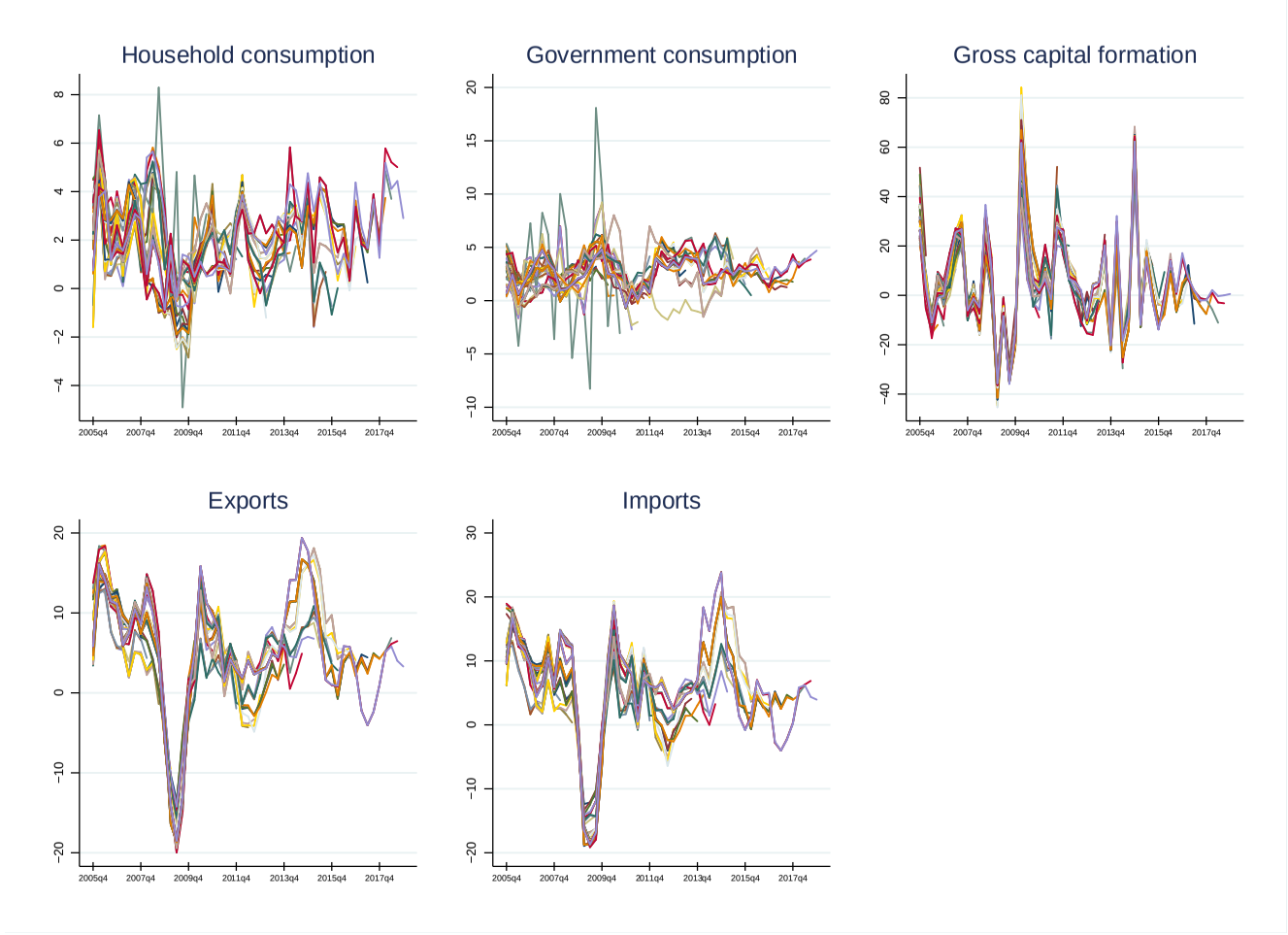
Appendices

Table A1: Dataset structure and sample size

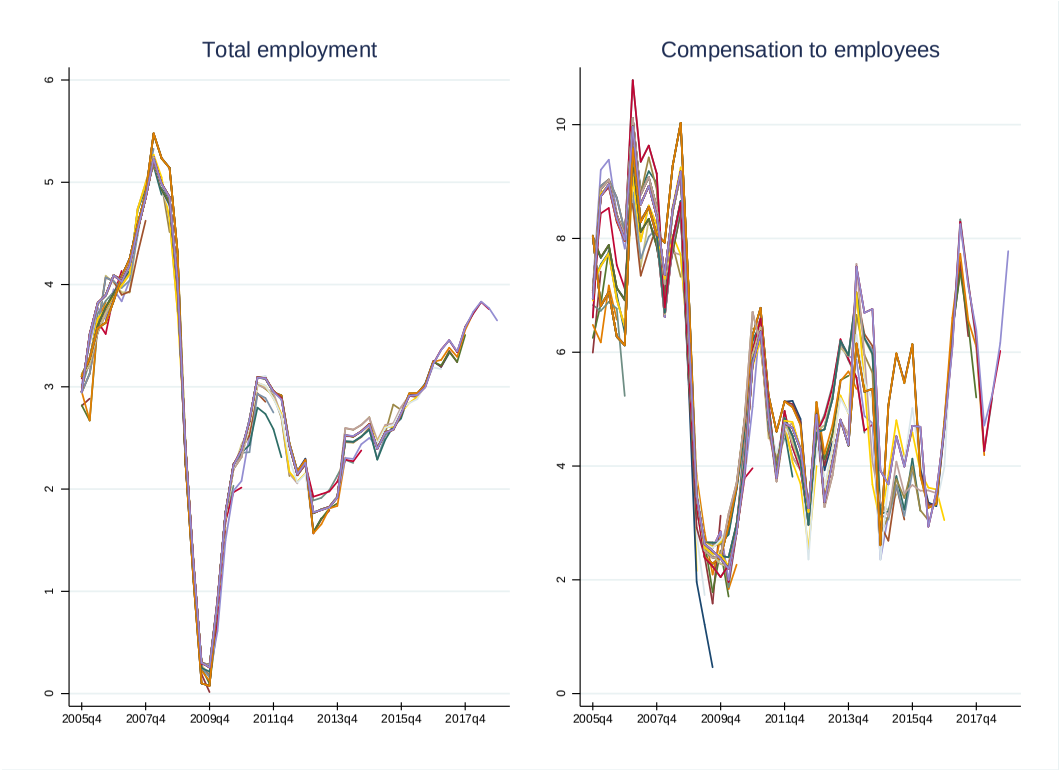
Vintage No.	Reference period	Release date	No. of obs.	Remarks
1	2005q4	April 2006	53	
2	2006q1	July 2006	52	
3	2006q2	October 2006	51	
4	2006q3	January 2007	50	
5	2006q4	April 2007	49	
6	2007q1	July 2007	48	
7	2007q2	October 2007	47	
8	2007q3	January 2008	46	
9	2007q4	April 2008	45	
10	2008q1	July 2008	44	
11	2008q2	October 2008	43	
12	2008q3	January 2009	42	
13	2008q4	April 2009	41	
14	2009q1	July 2009	40	
15	2009q2	October 2009	39	
16	2009q3	January 2010	38	
17	2009q4	April 2010	37	
18	2010q1	July 2010	36	
19	2010q2	October 2010	35	
20	2010q3	January 2011	34	
21	2010q4	April 2011	33	
22	2011q1	July 2011	32	
23	2011q2	October 2011	31	Price year base change (2005)
24	2011q3	January 2012	30	
25	2011q4	April 2012	29	
26	2012q1	July 2012	28	
27	2012q2	October 2012	27	
28	2012q3	January 2013	26	
29	2012q4	April 2013	25	
30	2013q1	July 2013	24	
31	2013q2	October 2013	23	
32	2013q3	January 2014	22	
33	2013q4	April 2014	21	
34	2014q1	July 2014	20	
35	2014q2	October 2014	19	ESA 2010 and methodological changes
36	2014q3	January 2015	18	
37	2014q4	July 2015	17	no STATEC release in April 2015
37	2015q1	July 2015	16	Price year base change (2010)
38	2015q2	October 2015	15	
39	2015q3	January 2016	14	
40	2015q4	April 2016	13	
41	2016q1	July 2016	12	
42	2016q2	October 2016	11	
43	2016q3	January 2017	10	
44	2016q4	April 2017	9	
45	2017q1	July 2017	8	
46	2017q2	October 2017	7	
47	2017q3	January 2018	6	
48	2017q4	April 2018	5	
49	2018q1	July 2018	4	
50	2018q2	October 2018	3	
51	2018q3	January 2019	2	
52	2018q4	April 2019	1	
			1395	

Figure A1: Vintages of y-o-y real growth by GDP expenditure component
(in percent)



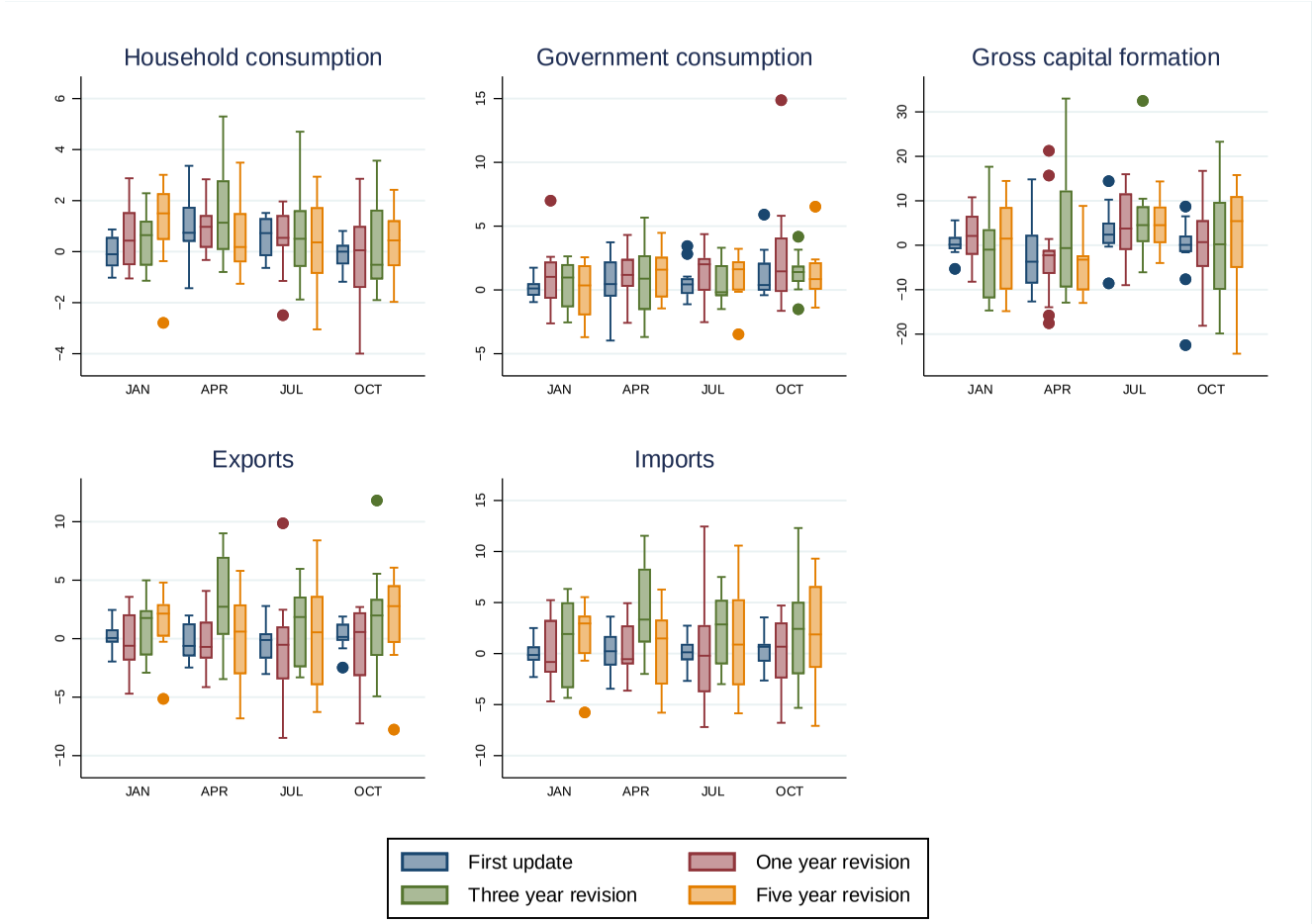
Source: STATEC, author's representation

Figure A2: Vintages of y-o-y growth in total employment and compensation to employees
(in percent)



Source: STATEC, author's representation

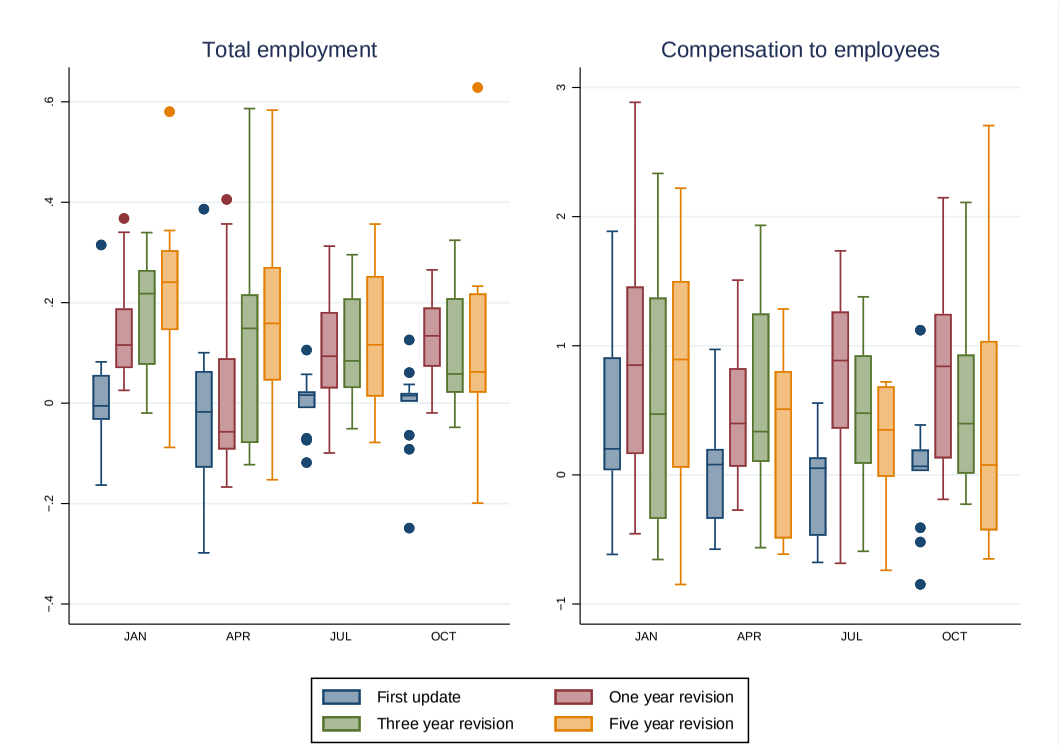
Figure A3: Revisions to y-o-y real growth by GDP expenditure component and calendar month of release
(in percentage points)



Note: Whiskers show the upper and lower adjacent value and dots represent outliers.

Source: STATEC, own calculations

Figure A4: Revisions to y-o-y growth in total employment and compensation to employees by calendar month of release
(in percentage points)



Source: STATEC, own calculations

Table A2: News vs. Noise: Regression analysis at three and five year horizons

	Dependent variable							
	3-year revision				5-year revision			
Variable	**Intercept**	**Coeff.**	**F-Stat**	**Prob.**	**Constant**	**Coeff.**	**F-Stat**	**Prob.**
GDP	-0,0007	0,0669	0,84	0,36	-0,0053	0,1897	2,00	0,17
	(0,0035)	(0,0729)			(0,0037)	(0,1342)		
Household consumption	0,0148**	-0,5204*	**3,69**	**0,06**	0,0126***	-0,5467***	**12,93**	**0,00**
	(0,0063)	(0,2709)			(0,0040)	(0,1520)		
Government consumption	0,0221***	-0,7527***	**78,99**	**0,00**	0,0229***	-0,8426***	**58,14**	**0,00**
	(0,0024)	(0,0847)			(0,0045)	(0,1110)		
Gross capital formation	0,0226	-0,0231	0,02	0,88	0,0157	-0,2251*	**3,57**	**0,07**
	(0,0214)	(0,1577)			(0,0171)	(0,1191)		
Exports	0,0171	0,0209	0,02	0,88	0,0077	0,0030	0,00	0,99
	(0,0110)	(0,1428)			(0,0157)	(0,2077)		
Imports	0,0244*	0,0458	0,08	0,78	0,0151	-0,0354	0,03	0,87
	(0,0126)	(0,1590)			(0,0175)	(0,2177)		

*Notes:*Standard errors in parentheses; $^{*}p \leq 0.1$, $^{**}p \leq 0.05$, $^{***}p \leq 0.01$. Sample of 41 obs. (3-year revision) and 32 obs. (5-year revision). F-Statistics apply heteroscedasticity and autocorrelation-robust Wald tests (Newey-West estimator). F-Statistics printed in bold are significant at a 10% level.

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