London Group on Environmental Accounting

Empirical Evaluation of Seasonal Adjustment of Time Series For Compiling Quarterly GHG Emissions Account

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Abstract

This paper examines the seasonal adjustment procedure used by the IMF when estimating global and regional quarterly greenhouse gas emissions. To our knowledge, this is the first study that uses both economic and emission and heating degree days data with a broad geographical coverage to evaluate a seasonal adjustment procedure.

We apply X11 of the X13-ARIMA-SEATS seasonal adjustment program to seven types of economic series and two types of emissions and heating degree days series. We study the difference between these types of series by evaluating six different empirical scenarios and show how the results support the IMF's current procedure for reporting global and regional quarterly GHG emissions. Our study shows that X11 seasonal adjustment method is data agnostic and works as well for emissions and heating degree days series as it does for economic series, and the airline model can be used first as a simpler model for both types of series. The finding that the scenarios yield similar but not exact outcomes when X11 seasonal adjustment method is applied to economic and emissions series could potentially pave the way for further investigation into the fundamental seasonal factors influencing emissions data. This large-scale study also identifies a limited number of series where the IMF could benefit from seeking exhaustive knowledge on calendar effects and breaks, and encourages data providers to allocate more resources to producing seasonally adjusted series. Finally, the paper recommends to guide user's intervention with further research into the use of X11 on series with at least one zero value, which might mimic emission data when the net zero emission target and transition energy policy are implemented.

[1] The views expressed are those of the authors and do not necessarily represent the views of the International Monetary Fund (IMF), its Executive Board, or IMF management. We thank Jim Tebrake, Erich Strassner, Marco Marini, Jennifer Ribarsky, Michael Stanger, Jens Mehrhoff, Bhanumati P. and Dominique Ladiray for their kind review. Errors and omissions remain the sole responsibility of the authors.

Outline

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I. Introduction

This paper aims to evaluate whether X11 with automatic selection model mainly designed for economic series also performs well on climate change related series and the extent to which deviation from good practice in seasonal adjustment method might lower the quality of the results. The result of this evaluation will be used to improve the IMF production system, which uses a seasonal adjustment method in two different steps to prepare global and regional quarterly GHG emissions account. The IMF released the first quarterly GHG emissions account with the launch of its Climate Change Indicator Dashboard[2] in July 2021 to track GHG emissions, which are far in excess of current national commitments aiming to cap global warming increase below 2°C, with similar boundaries, geographical coverage, frequency and timeliness as national accounts. Seasonally adjusted quarterly GHG emissions further supports analytical frameworks that combine emissions and economic data for informed policy making, especially when short-term targets are urgently needed for mitigation. As shown in this study, economic and emissions and heating degree days series fluctuate strongly across seasons depending on temperature, weather, social conventions (holidays and vacations) and underlying economic activity. For more details on what causes seasonal patterns in economic and emissions and heating degree days series, we refer interested readers to Astolfi and Pegoue (2023) and the IMF's book Data for a Greener World: A Guide for Practitioners and Policymakers.

The paper contributes to empirical evaluation of seasonal adjustment methods on large scale studies such as Fischer and Planas (2000) and Tiller et. al (2007), with an extended scope that includes emissions and heating degree days data useful to prepare quarterly GHG emissions from 2010 onward. To our knowledge, this is the first study that uses both economic and emissions and heating degree days data with a larger geographical coverage to evaluate seasonal adjustment methods. The study is based on 5,140 times series from 157 economies. The IMF prepares the database leveraging cooperation among international organizations and using publicly available databases to reduce duplication and workload, including detailed quarterly GHG emission estimates prepared by Eurostat, monthly energy and heating degree days data from the International Energy Agency (IEA), and monthly CO_2 emission data from the U.S. Energy Information Administration (EIA).

The IMF releases seasonally adjusted quarterly GHG emissions data because for some countries only seasonally adjusted sub-annual indicators are available for certain categories. Furthermore, seasonally adjusted data allow for time series that are easier to interpret, analyze and forecast. Therefore, the IMF seasonally adjusts any unadjusted sub-annual series to supplement existing seasonally adjusted sub-annual series published by the country to create a comprehensive seasonally adjusted database that serves as the input into the temporal disaggregation of annual GHG emissions at the country level for non-European Union (EU) countries. The results for the non-EU countries are then combined with Eurostat's quarterly GHG estimates, which are seasonally adjusted by the IMF, to temporally disaggregate the regional annual GHG emissions data.[3] The IMF's book Data for a Greener World: A Guide for Practitioners and Policymakers provides details on Eurostat's and IMF's methodologies to compile the quarterly GHG emissions account.[4] The IMF would like to release unadjusted quarterly GHG emissions data in November 2023, so that users can distinguish movements that are due to the underlying source data from those that are attributable to seasonal adjustment. The production of unadjusted quarterly GHG emission data will be possible

[2] https://climatedata.imf.org/

[3] The countries without sub-annual data (energy statistics, indices of industrial production, gross value-added) are grossed up based on estimates for countries in their region. The IMF's Climate Change Indicators Dashboard publishes data at the regional level even though they are estimated at the country level.

[4] The chapter summarizes the IMF's estimation process and Annexes 1.1 and 1.2 provide more details of the estimation plan.

because of the ongoing work to increase the number of unadjusted sub-annual time series selected based on qualitative[5] and quantitative[6] criteria before being temporally disaggregated to annual GHG emissions account. The IMF production system is implemented in R software where the package provides an interface with X13-ARIMA-SEATS as developed by the US Census Bureau.

We compare X11 seasonal adjustment diagnostics as implemented in X13-ARIMA-SEATS across nine types of series divided into economic series (energy, external trade, gross value added, index of industrial production, labor force, price-adjusted turn-over and transportation) and emissions and heating degree days serie. The first range of diagnostic evaluates the presence of seasonality using chi-square (QS) test and Fisher test (F-test) for stable seasonality while the second range focuses on the quality of seasonal adjustment using M-statistics. The study also evaluates whether seasonally adjusted series resulting from the use of automatic selection model of X13-ARIMA-SEATS differ from the ones produced by the well-known airline model and the ones collected from data providers. The four metrics used for this evaluation are the mean absolute percentage deviation, root mean square percentage deviation and coincidence on year-on-year and quarter-to-quarter change.

The remaining part of the paper is organized as follows. The second section presents three datasets that are seasonally adjusted in this study and used in the evaluation, namely the IMF sub-annual series without zero value, IMF sub-annual series with at least one zero value, and the Eurostat quarterly GHG emissions account. The third section outlines the diagnostic tests, quality control and metrics for percentage error and coincidence of change. The fourth section evaluates six different empirical scenarios ((i)presence of seasonality in unadjusted data; (ii) quality control of seasonal adjustment results; (iii) difference between automatic modelling and the airline model; (iv) presence of residual and induced seasonality; (vi) difference between automatic modelling and country modelling) as well as their implications for the IMF production system. The fifth section concludes with the major findings and their implications for the IMF production system and the limitations of this study

II. Data

The IMF collects sub-annual indicators from publicly available sources every quarter as follows:

- IEA electricity statistics, and weather for energy tracker (IEA, 2021, 2022a, 2022b).
- Gross value-added in constant prices (IMF and OECD, quarterly).
- Index of industrial production (United Nations Industrial Development Organization [UNIDO], quarterly; IMF, Australian Bureau of Statistics [ABS] and Central Bank of Western African States [BCEAO], monthly).
- Data for the United States on carbon dioxide emissions (U.S. Energy Information Administration [EIA], monthly); on value-added by industry (U.S. Bureau of Economic Analysis [BEA], quarterly); on construction spending (U.S. Census Bureau, monthly); on meat production (U.S. Department of Agriculture [USDA], quarterly).
- External trade (IMF and World Trade Organization [WTO], monthly).
- Transportation data (OECD, quarterly).
- Labor force (IMF, monthly).

[5] Specifically, prior assumption on relationship between annual GHG emissions account and sub-annual series.

[6] Specifically, correlation coefficient between annual GHG emissions account and annualized sub-annual series.

These IMF sub-annual series are divided into series without a zero value and series with at least one zero value, as shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**. The contribution of each type of indicator and region to total emissions is provided in Table 9. Series with at least one zero value form a specific dataset to evaluate because they may reflect the behavior of emission series decreasing toward zero emissions. As shown in Figure 1, series with at least one zero value or trending toward zero values do not pose a specific problem to seasonal adjustment technique, as far as a seasonal pattern is clearly identified. However, presence of zero values will prevent any log-transformation to dampen down the heteroscedastic variance, resulting in unstable seasonality and higher failure of F-test for stable seasonality presented in section III. We have yet to investigate the solution of adding a constant value to lift the series as this will affect all calculations using rates of change.

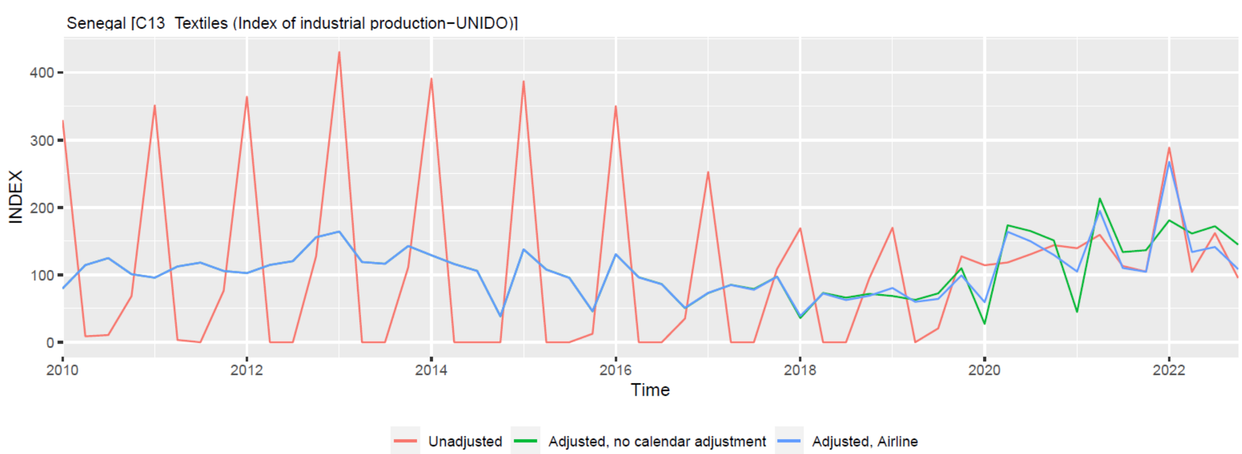
Table 1: Availability of time series

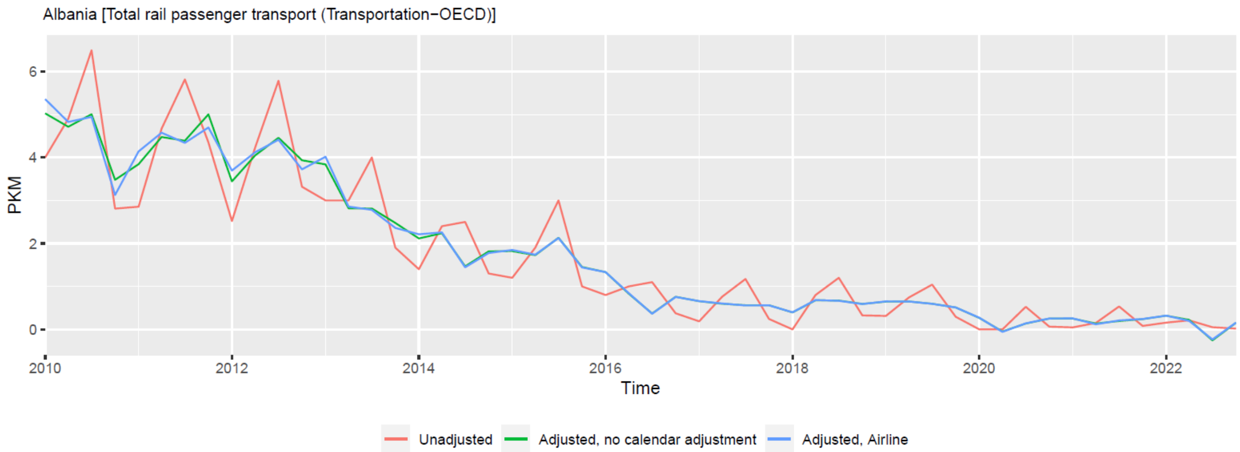
Type of series	IMF series without a zero value		IMF series with at least one zero value		Eurostat quarterly GHG emissions series	**Total (without missing data)**
	All	Without missing data	All	Without missing data		
Total Unadjusted	**5 428**	**3 738**	**199**	**160**	**1 242**	**5 140**
Economic series	**5 183**	**3 493**	**70**	**31**	**1 107**	**4 631**
Energy	*689*	*548*	*36*	*10*	*108*	***666***
External trade	*146*	*146*	-	-	-	***146***
Gross value added	*633*	*562*	-	-	*918*	***1 480***
Index of industrial production	*3 258*	*2 051*	*28*	*18*	*54*	***2 123***
Labor force	*63*	*35*	-	-	-	***35***
Meat[1]	*140*	*0*	-	-	-	***0***
Price-adjusted turnover index	-	-	-	-	*27*	***27***
Transportation	*254*	*151*	*6*	*3*	-	***154***
Emissions and heating degree days series	**245**	**245**	**129**	**129**	**54**	**428**
Emissions	*50*	*50*	*1*	*1*	*27*	***78***
Heating degree Days	*195*	*195*	*128*	*128*	*27*	***350***
No predictor	-	-	-	-	*81*	***81***

Source: *ABS, BCEAO, BEA, EIA, Eurostat, IEA, IMF, OCDE, USDA, UNIDO and IMF calculations*

Note: 1/ Meat-type is excluded from the analysis.

Figure 1: Examples of seasonal adjustment of series with zero values





Source: UNIDO, OECD and Authors' calculations

Note:
1/ PKM: Passenger-Kilometer.
2/ Unadjusted: unadjusted series of textile UNIDO Index of industrial production for Senegal and OECD rail passenger transport for Albania.
3/ Adjusted, no calendar adjustment: series seasonally adjusted with X11 automatic selection model without calendar adjustment.
4/ Adjusted, Airline: series seasonally adjusted with X11 using the airline model in pre-adjustment phase and without calendar adjustment.

The database also contains unadjusted quarterly GHG emissions data prepared by Eurostat and shared with the Task Team on estimating quarterly GHG emissions[7]. The methodology developed by Eurostat [8] includes a concordance table between a condensed annual level of detail for the quarterly estimation (46 categories of NACE/ISIC industries and household activities by GHG combinations) and sub-annual predictors. The weighted shares of the sub-annual predictors (representing 1 242 time series) used to construct the EU27 total unadjusted quarterly GHG estimates is presented in Annex B Table 10. The IMF seasonally adjusts the Eurostat unadjusted quarterly GHG emissions data and combines them with the IMF non-EU seasonally adjusted quarterly GHG estimates to temporally disaggregate the data to regional quarterly GHG emissions account. It should be noted that the seasonal pattern in the EU 27 data is driven by the sub-annual series used as predictors, annual benchmarks and temporal disaggregation techniques.

The study considers only series without missing data. The number of time series decreases from 5,428 to 3,738 when series with missing data are excluded from the database of series without a zero value, and from 199 to 160 from the database of series with at least one zero value. We also excluded series that generated negative values (for IMF series without a zero value, 13 out of 15 series excluded are energy-type). We agree with one reviewer's comment that these exclusions increase the selection bias of this study, which is not mitigated using proportion.

[7] The Task Team was created in 2021 and is composed of Eurostat, IMF, IEA, OECD and United Nations Statistics Division.

[8] Available from https://www.imf.org/en/Publications/Books/Issues/2023/04/04/Data-for-a-Greener-World-A-Guide-for-Practitioners-and-Policymakers-522462 and https://ec.europa.eu/eurostat/documents/1798247/6191529/Methodological-note-on-quarterly-GHG-estimates.pdf/6bd54bde-4dd7-ebac-6326-f08c73eb9187?t=1644394935594

The classification of series by type (economic series (energy, external trade, gross value added, index of industrial production, labor force, price-adjusted turn-over and transportation) and emissions and heating degree days series is either direct or indirect, to avoid including Eurostat quarterly GHG emission series under emission-type series. The direct classification applies to IMF sub-annual indicators, whereby the name of the series allows its inclusion in one type of series. For instance, UNIDO series, which are composed of 34 industries, are included in the index of industrial production type. Similarly, US emission series, which are composed of 54 categories organized by sector and source, is included in emission type. Energy series, which are composed of 20 categories organized by transaction and source, are included in climate change related series because they are key data to prepare climate change related statistics including emission series. The indirect classification applies to Eurostat quarterly GHG emissions accounts, whereby we use the underlying sub-annual predictor to associate the 46 categories of the account to the nine types of series. For instance, net electricity generation from combustible fuels is the predictor for carbon dioxide emissions from electricity industry, which is therefore classified in in energy type under climate change related series. Similarly, gross value added is the predictor for 26 categories including methane emissions from household and mining, manufacturing, electricity, construction, trade, transportation and other service industries, which are classified in gross value added type under economic series. The "no predictor" type, which applies to categories including methane emissions from agriculture and the water, sewage and waste management industries, as well as nitrous oxide emissions from agriculture industry, is excluded from this study and presented for completeness.

III. Methodology

The implementation of seasonal adjustment method in X11 of X13-ARIMA-SEATS with automatic selection model requires some prior assumptions which are allegedly based on economic series. These assumptions are necessary either to start the seasonal adjustment procedure or to provide a limited number of possibilities to test. X13-ARIMA-SEATS reference manual indicates that "*The modeling module of X-13ARIMA-SEATS is designed for regARIMA model building with seasonal economic time series. To this end, several categories of predetermined regression variables are available in X-13ARIMA-SEATS including trend constants or overall means, fixed seasonal effects, trading-day effects, holiday effects, pulse effects (additive outliers), level shifts, temporary change outliers, and ramp effects*". For illustration, the default seasonal adjustment mode is multiplicative "*because, for most seasonal economic time series, the magnitudes of the seasonal fluctuations appear to increase and decrease proportionally with increases and decreases in the level of the series, in a way that is proportional to the level".* It is also likely that the automatic seasonal filter selection feature (3x3, 3x5, or 3x9 moving average) and use of the airline model as the default model estimation are based on economic data. It should be noted that the capabilities of X13-ARIMA-SEATS allows expert user with knowledge about the series being modelled to customize the identification and estimation stages, which is not feasible in a large-scale study.

To evaluate if X11 with automatic model selection also works on climate change related series, our proposed strategy is twofold.

First, we evaluate whether proportions of series with presence of seasonality and good quality control diagnostics are significantly different across the nine types of series. This study uses two tests to detect presence of seasonality:

- The chi-square (QS) tests the null hypothesis of no seasonality based on a statistic related to two autocorrelations of seasonal order that follows a chi-square distribution. High values of QS may indicate the presence of seasonality. The threshold of QS is 6, which correspond to a test rejection for nominal significance level of 0.05. In the analysis, we focus on series with QS larger than 6, i.e., the number or percentage of series with presence of seasonality. Two QS presented in this study are calculated on the unadjusted series and adjusted series.

- The F-test for stable seasonality is a test generated from a chi-square statistic to test the null hypothesis that coefficients of fixed seasonal regressors in the regARIMA model are collectively zero. In the analysis, we focus on series with stable seasonality i.e., significance level of 0.5. Two F-test for stable seasonality presented in this study are calculated on the unadjusted series and the adjusted series.

We also use two diagnostics to evaluate the quality control on series with seasonality. M7 diagnostics measures the relationship between moving and stable seasonality. Too much moving seasonality may cause problems in the estimation of the series components. QM2 diagnostics is a weighted average of M1 and M3-M11 diagnostics[9] and large QM2 indicates poor adjustment. The threshold for M7 and QM2 is one, and analysis focuses on the number or percentage of time series that are marginal or passing the quality control test, i.e., M7 and QM2 smaller than one. The Quarterly National Accounts Manual clarifies that the quality of the whole process could still be deemed appropriate even when some of the diagnostics are larger than one.

Second, we compare benchmark to estimate series[10] using three metrics:

- Mean Absolute Percentage Deviation (MAPD) calculated as $100 \times \frac{1}{n}\sum_{i=1}^{n}\left|\frac{\text{Estimates}_i - \text{Benchmarks}_i}{\text{Benchmarks}_i}\right|$
- Root Mean Square Percentage Deviation (RMSPD) calculated as $100 \times \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{\text{Estimates}_i - \text{Benchmarks}_i}{\text{Benchmarks}_i}\right)^2}$
- Year-on-year (y-on-y) and quarter-to quarter (q-to-q) coincidence, which measures the extent to which changes in both series overlap, calculated as $100 \times \frac{1}{n}\sum_{i=1}^{n} 1_{(\text{Estimates}_i\,,\text{Benchmarks}_i)}$, where the indicator function $1_{(\text{Estimates}_i\,,\text{Benchmarks}_i)} = 1$ if $sign(\text{Estimates}_i - \text{Estimates}_{i-k}) = sign(\text{Benchmarks}_i - \text{Benchmarks}_{i-k})$ and $1_{(\text{Estimates}_i\,,\text{Benchmarks}_i)} = 0$ elsewhere, with $k = 4$ for y-on-y and $k = 1$ for q-to-q.

One reviewer suggested that a proportion test might be useful for comparing proportions within each statistic or diagnostic. We use the chi-square test for equal proportions of the ten types of series under the null hypothesis and consider a test rejection for 0.05 level of significance. In the analysis, the commentary focuses on statistics and diagnostics for which there is a presumption that the hypothesis of equal proportions is rejected.

IV. Empirical Results and Discussion

The diagnostic tests, quality control and metrics presented in this section are based on X11 with automatic model selection, unless otherwise stated.

[9] As explained in the Quarterly National Accounts Manual (pages 153-154), M1 and M2 show the size of the irregular component in the series, M3 and M5 calculate the significance of the irregular component in relation to the trend cycle, M4 shows the amount of autocorrelation in the irregular, M6 compares the (annual) stability of seasonality with respect to changes in the irregular component, and M8-M11 deal with the stability of the seasonal component.

[10] "Estimates" denotes an adjusted series produced with the X11 method and automatic model selection of X13-ARIMA-SEATS. "Benchmarks" denotes an adjusted series produced with X11 method with the airline model of X13-ARIMA-SEATS or an adjusted series prepared by countries or other international organizations.

A. ARE ECONOMIC DATA MORE PRONE TO SEASONALITY THAN EMISSIONS AND HEATING DEGREE DAYS DATA?

To answer this question, QS and F-test on original data are considered in Table 2. In general, time series are all prone to seasonality with an average of eight to ten on the QS test for presence of seasonality and an average of nine out of ten on the F-test for stable seasonality. For IMF series, heating degree days, labor force and gross value added are more prone to seasonality than other type of time series. Proportions of series with presence of seasonality in Emissions, energy and index of industrial production types are near 78 percent, which is the average proportion across all types, while external trade and transportation are less prone to seasonality than other time series. The finding that the use of emission-type predictor to temporally disaggregate annual GHG emissions account results in quarterly series less prone to seasonality needs further investigation that includes to look into contribution of predictors, annual benchmarks and temporal disaggregation techniques.

The implication for the IMF production system is that there is no need to perform the seasonal adjustment method for one quarter of time series, as there is no provision in the current system to exclude series without seasonal pattern. Seasonal adjustment is time-consuming and reducing the number of series would decrease compilation and review time. This finding is encouraging as the IMF production system has scheduled to integrate a framework to review seasonal adjustment diagnostics in a later stage of the development of its production system to reduce the number of series failing diagnostic tests or exceeding quality control.

Table 2: Presence of seasonality in unadjusted time series

Type	IMF series without zero a value			IMF series with at least one zero value			Eurostat quarterly GHG emission series		
	#Series	QS	F-Test	#Series	QS	F-Test	#Series	QS	F-Test
Overall	**3 700**	**77.7**	**91.6**	**27**	**96.3**	**96.3**	**1 197**	**78.5**	**89.1**
Economic series	3 455	76.5	91.1	8	87.5	87.5	1 155	79.0	88.9
Energy	*519*	*79.4*	*90.2*	*2*	*100.0*	*50.0*	*106*	*73.6*	*95.3*
External trade	*146*	*62.3*	*94.5*	-	-	-	-	-	-
Gross value added	*561*	*87.9*	*96.1*	-	-	-	*891*	*86.1*	*95.2*
Index of industrial production	*2 047*	*74.7*	*89.8*	*5*	*80.0*	*100.0*	*52*	*76.9*	*92.3*
Labor force	*35*	*88.6*	*94.3*	-	-	-	-	-	-
Price-adjusted turnover index	-	-	-	-	-	-	*25*	*96.0*	*100.0*
Transportation	*147*	*59.2*	*89.1*	*1*	*100.0*	*100.0*	-	-	-
Emissions and heating degree days series	245	94.3	99.2	19	100.0	100.0	42	66.7	92.9
Emissions	*50*	*78.0*	*96.0*	-	-	-	*15*	*6.7*	*80.0*
Heating degree Days	*195*	*98.5*	*100.0*	*19*	*100.0*	*100.0*	*27*	*100.0*	*100.0*
No predictor	-	-	-	-	-	-	*81*	*3.7*	*6.2*
p.value of proportion test		*0.000*	*0.000*		*0.218*	*0.009*		*0.000*	*0.000*

Source: ABS, BCEAO, BEA, EIA, Eurostat, IEA, IMF, OCDE, UNIDO and Authors' calculations.

Note:

#Series: number of series successfully seasonally adjusted	QS: Percentage of series with presumption of seasonality in unadjusted series (significance level of 5 percent or QS greater 6)	F-Test Percentage of series with presumption of stable seasonality in unadjusted series (significance level of 5 percent)

B. DO ECONOMIC DATA PASS QUALITY CONTROL TEST MORE THAN EMISSIONS AND HEATING DEGREE DAYS DATA?

To answer this question, M7 and QM2 are evaluated on a subset of series with presumption of seasonality in

Table 3. The overall quality of seasonal adjustment QM2 is lower for emission and energy type time series than other types of time series. As shown in Table 11 in the annex, similar results are found when the X11 with the airline model is performed on the same set of data, though percentage of time series passing M7 and QM2 improves for series with at least one zero value and for emission and energy-type time series. Exceedance of quality control should be considered as there are signs that X11 moving averages might behave poorly.

Given these results, the IMF production system needs to dedicate more time to review quality control diagnostics for emission and energy type time series. Other M-diagnostics for QM2 exceeding 1 show (i) highly irregular series (M1); (ii) difficulty in extracting the trend-cycle component (M3 and M5); (iii) high fluctuations in the seasonal pattern, which may reveal the existence of abrupt seasonal breaks (M8), mainly at the end of the series (M10). Calendar adjustment, improved outlier identification and seasonal adjustment according to appropriate periods to consider breaks can help improve these M diagnostics for almost 200 series (almost five percent of a total four thousand series have M7 and QM2 that exceed one).

Table 3: Quality control diagnostics of seasonal adjustment for X11 with automatic model selection

Type	IMF series without a zero value			IMF series with at least one zero value			Eurostat quarterly GHG emission series		
	#Series	M7	QM2	#Series	M7	QM2	#Series	M7	QM2
Overall	**2 875**	**96.7**	**93.2**	**26**	**92.3**	**88.5**	**940**	**98.6**	**98.5**
Economic series	2 644	96.5	92.9	7	71.4	57.1	912	98.7	98.5
Energy	*412*	*95.1*	*88.6*	*2*	*50.0*	*50.0*	*78*	*98.7*	*96.2*
External trade	*91*	*98.9*	*91.2*	-	-	-	-	-	-
Gross value added	*493*	*97.4*	*95.9*	-	-	-	*767*	*98.7*	*98.7*
Index of industrial production	*1 530*	*96.3*	*92.9*	*4*	*75.0*	*50.0*	*40*	*97.5*	*100.0*
Labor force	*31*	*100.0*	*100.0*	-	-	-	-	-	-
Price-adjusted turnover index	-	-	-	-	-	-	*24*	*100.0*	*100.0*
Transportation	*87*	*97.7*	*94.3*	*1*	*100.0*	*100.0*	-	-	-
Emissions and heating degree days series	231	99.1	97.0	19	100.0	100.0	28	96.4	100.0
Emissions	*39*	*97.4*	*84.6*	*1*	*0.0*	*0.0*	*1*	*0.0*	*100.0*
Heating degree Days	*192*	*99.5*	*99.5*	*19*	*100.0*	*100.0*	*27*	*100.0*	*100.0*
No predictor	-	-	-	-	-	-	*3*	*100.0*	*66.7*
p.value of proportion test		*0.053*	*0.000*		*0.014*	*0.001*		*0.000*	*0.648*

Source: ABS, BCEAO, BEA, EIA, Eurostat, IEA, IMF, OCDE, UNIDO and Authors' calculations.

Hint:

#Series: number of original series with presumption of seasonality	M7: Percentage of series with presumption of lower moving seasonality relative to stable seasonality (M7 less than 1)	QM2: Percentage of series with presumption of good quality control statistics (QM2 less than 1)

C. IS THE AIRLINE MODEL MORE SUITABLE FOR ECONOMIC DATA THAN EMISSIONS AND HEATING DEGREE DAYS DATA?

Before addressing this question in terms of distance between adjusted series with X11 with airline model and automatic model selection[11], we first illustrate how often the airline model is selected within automatic model selection on a subset of time series with presumption of seasonality in Table 4. On average, the airline model is selected as the final ARIMA model for 20 percent of time series with presumption of seasonality. The lowest percentage is seen for emissions heating degree days (6 percent) and IMF emissions (15 percent). The airline model is barely identified among the five best ARIMA model for heating degree days (0 percent) and IMF energy (14 percent). Energy used as Eurostat predictor led to 35 percent of series with airline model among the best five and 41 percent of series with airline model as the final ARIMA model. For emissions, energy, labor force and gross value added, the airline model's residual diagnostic supersedes the Bayesian Information Criteria (BIC) for more than 10 percent of time series.

Table 4: Selection of airline model in the pre-adjustment phase

Type	IMF series without a zero value			IMF series with at least one zero value			Eurostat quarterly GHG emission series		
	#Series	Best 5	Final	#Series	Best 5	Final	#Series	Best 5	Final
Overall	**2 875**	**24.3**	**22.4**	**26**	**3.8**	**3.8**	**940**	**22.0**	**16.1**
Economic series	2 644	26.1	23.8	7	0.0	0.0	912	22.7	16.4
Energy	*412*	*13.6*	*23.1*	*2*	*0.0*	*0.0*	*78*	*34.6*	*41.0*
External trade	*91*	*31.9*	*36.3*	-	-	-	-	-	-
Gross value added	*493*	*37.1*	*24.7*	-	-	-	*767*	*20.6*	*13.6*
Index of industrial production	*1 530*	*25.4*	*22.9*	*4*	*0.0*	*0.0*	*40*	*27.5*	*25.0*
Labor force	*31*	*38.7*	*22.6*	-	-	-	-	-	-
Price-adjusted turnover index	-	-	-	-	-	-	*24*	*41.7*	*16.7*
Transportation	*87*	*25.3*	*23.0*	*1*	*0.0*	*0.0*	-	-	-
Emissions and heating degree days series	231	4.3	7.4	19	5.3	5.3	28	0.0	3.6
Emissions	*39*	*25.6*	*15.4*	*1*	*0.0*	*0.0*	*1*	*0.0*	*0.0*
Heating degree Days	*192*	*0.0*	*5.7*	*19*	*5.3*	*5.3*	*27*	*0.0*	*3.7*
No predictor	-	-	-	-	-	-	*3*	*33.3*	*0.0*
p.value of proportion test		*0.000*	*0.000*		*0.979*	*0.979*		*0.000*	*0.000*

Source: ABS, BCEAO, BEA, EIA, Eurostat, IEA, IMF, OCDE, UNIDO and Authors' calculations.

Note:

#Series: number of original series with presumption of seasonality	Airline Best 5: Percentage of series selecting airline among the five best ARIMA models	Airline Final: Percentage of series selecting airline as the final ARIMA model

[11] In the pre- adjustment phase of X13-ARIMA-SEATS with the automatic model selection, a set of regressors are estimated in the regARIMA module based on TRAMO procedure for modeling certain kinds of disruptions in the series, or sudden changes in level, whose effects need to be temporarily removed from the data before the X-11 methodology (a set of centered moving averages to estimate the seasonal components) can adequately estimate seasonal adjustments. The airline model is the default ARIMA model in this phase.

Table 5 compares average deviation (MAPD) and spread (RMSPD) as well as coincidences between adjusted series with airline model and automatic model selection for X11. Lower MAPD and RMSPD, and higher coincidences reflect proximity between the two adjusted series. There is a risk to use the airline model to seasonally adjust IMF series with at least one zero value and Eurostat unadjusted quarterly GHG emissions that use heating degree days as a predictor. This finding has a limited scope due to the number of series available for the analysis.

For the IMF production system, X11 with the airline model in the pre-adjustment phase will produce reasonable estimates and reduce compilation time in the search of the best model, except for Eurostat unadjusted quarterly GHG emissions that use heating degree days as a predictor. For instance, the compilation time for IMF series without a zero value is reduced by one-third from two hours and 45 minutes for X11 with automatic model selection to two hours for X11 with the airline model. Though the processing time is reduced by nearly one-third, we will continue to use X11 with automatic model selection as it produces more accurate seasonally adjusted estimates.

Table 5: Metrics for percentage deviation and coincidence between adjusted series with airline model and automatic selection for X11.

Type	IMF series without a zero value					IMF series with at least one zero value					Eurostat quarterly GHG emission series				
	#Series	MAPE	RMSPE	q-to-q	y-on-y	#Series	MAPE	RMSPE	q-to-q	y-on-y	#Series	MAPE	RMSPE	q-to-q	y-on-y
Overall	**2 875**	**0.2**	**1.0**	**98.4**	**99.7**	**26**	**5.5**	**19.9**	**92.1**	**95.9**	**940**	**0.2**	**4.6**	**98.5**	**99.8**
Economic series	2 644	0.2	0.8	98.4	99.7	7	3.2	8.8	98.3	99.7	912	0.1	0.3	98.5	99.8
Energy	*412*	*0.3*	*1.4*	*98.5*	*99.7*	*2*	*3.3*	*6.3*	*98.0*	*100.0*	*78*	*0.2*	*0.6*	*98.9*	*99.9*
External trade	*91*	*0.1*	*0.5*	*98.2*	*99.8*	-	-	-	-	-	-	-	-	-	-
Gross value added	*493*	*0.1*	*0.4*	*98.4*	*99.8*	-	-	-	-	-	*767*	*0.1*	*4.3*	*98.4*	*99.8*
Index of industrial production	*1 530*	*0.2*	*0.7*	*98.5*	*99.7*	*4*	*3.9*	*10.7*	*98.0*	*100.0*	*40*	*0.2*	*0.6*	*98.6*	*99.8*
Labor force	*31*	*0.1*	*0.2*	*98.4*	*99.9*	-	-	-	-	-	-	-	-	-	-
Price-adjusted turnover index	-	-	-	-	-	-	-	-	-	-	*24*	*0.1*	*0.3*	*98.9*	*99.8*
Transportation	*87*	*0.3*	*0.7*	*98.0*	*99.6*	*1*	*0.3*	*0.7*	*100.0*	*97.9*	-	-	-	-	-
Emissions and heating degree days series	231	0.6	2.3	98.3	99.5	19	6.3	22.8	89.7	94.4	28	2.1	14.5	97.6	99.5
Emissions	*39*	*0.3*	*1.3*	*98.5*	*99.6*	-	-	-	-	-	*1*	*1.4*	*2.8*	*96.1*	*100.0*
Heating degree Days	*192*	*0.6*	*2.4*	*98.2*	*99.5*	*19*	*6.3*	*22.8*	*89.7*	*94.4*	*27*	*2.1*	*14.5*	*97.6*	*99.5*
No predictor	-	-	-	-	-	-	-	-	-	-	*3*	*0.0*	*0.1*	*99.4*	*100.0*

Source: ABS, BCEAO, BEA, EIA, Eurostat, IEA, IMF, OCDE, UNIDO and Authors' calculations.

Note:

#Series: number of original series with presumption of seasonality	MAPE: Mean Absolute Percentage Deviation	RMSPE: Root Mean Square Percentage Deviation	q-to-q: quarter-to quarter coincidence	y-on-y: Year-on-year coincidence

D. ARE ECONOMIC DATA MORE PRONE TO RESIDUAL SEASONALITY THAN EMISSIONS AND HEATING DEGREE DAYS DATA?

Residual seasonality is the highest for IMF series with at least one zero value at a proportion of 8 percent. Combined with poor performance of the airline mode, this finding suggests that user might intervene to refine X11 specifications. This finding has a limited scope due to the number of series available for the analysis.

Heating degree days-type time series still display seasonal pattern for four percent of series in Eurostat quarterly GHG emission database and three percent in IMF series with at least one zero value. This finding is unexpected as quality control M7 and QM2 were good. A close look on other M diagnostics shows that the seasonal adjustment routine faces difficulty in extracting the trend-cycle component (exceedance of M3 and M5). On the overall, there is no finding that emission and energy-type time series are more prone to residual seasonality than economic time series.

For the IMF production system, failing to consider all M diagnostics might hamper the understanding of failure of residual seasonality test. This is difficult to consider in a large-scale study. On the whole, the finding that one percent of time series shows residual seasonality is encouraging and the figure would likely be further reduced if calendar effects are corrected. In the current production system, the parsimonious inclusion of Easter and five Muslim moving holidays is therefore a good option to maintain. The IMF strongly encourages countries to allocate more resources to the production of seasonally adjusted economic and emissions and heating degree days statistics as calendar effects can be properly corrected by the country.

Table 6: Percentage of time series with residual seasonality in the adjusted series

Type	IMF series without a zero value			IMF series with zero values			Eurostat quarterly GHG emission series		
	#Series	QS	F-Test	#Series	QS	F-Test	#Series	QS	F-Test
Overall	2 875	1.3	1.6	26	7.7	7.7	940	0.2	1.5
Economic series	2 644	1.2	1.5	7	0.0	14.3	912	0.1	1.4
Energy	*412*	*0.7*	*4.6*	*2*	*0.0*	*0.0*	*78*	*0.0*	*0.0*
External trade	*91*	*0.0*	*0.0*	-	-	-	-	-	-
Gross value added	*493*	*1.2*	*1.2*	-	-	-	*767*	*0.1*	*1.7*
Index of industrial production	*1 530*	*1.6*	*0.8*	*4*	*0.0*	*25.0*	*40*	*0.0*	*0.0*
Labor force	*31*	*0.0*	*3.2*	-	-	-	-	-	-
Price-adjusted turnover index	-	-	-	-	-	-	*24*	*0.0*	*0.0*
Transportation	*87*	*0.0*	*2.3*	*1*	*0.0*	*0.0*	-	-	-
Emissions and heating degree days series	231	2.2	2.2	19	10.5	5.3	28	3.6	3.6
Emissions	*39*	*0.0*	*2.6*	-	-	-	*1*	*0.0*	*0.0*
Heating degree Days	*192*	*2.6*	*2.1*	*19*	*10.5*	*5.3*	*27*	*3.7*	*3.7*
No predictor	-	-	-	-	-	-	*3*	*0.0*	*0.0*
p.value of proportion test		*0.439*	*0.000*		*0.902*	*0.749*		*0.000*	*0.765*

Source: ABS, BCEAO, BEA, EIA, Eurostat, IEA, IMF, OCDE, UNIDO and Authors' calculations.

Note:

#Series: number of original series with presumption of seasonality

QS: Percentage of adjusted series with presumption of seasonality (significance level of 5 percent or QS greater than 6)

F-Test Percentage of adjusted series with presumption of stable seasonality (significance level of 5 percent)

E. ARE ECONOMIC DATA MORE PRONE TO INDUCED SEASONALITY THAN EMISSIONS AND HEATING DEGREE DAYS DATA?

Induced seasonality refers to presence of residual seasonality into the seasonally adjusted series when the unadjusted series has no seasonal pattern (Hood 2002). To answer the question, QS on adjusted series is evaluated on a subset of series with no seasonal pattern [QS smaller than 3.2 or significance level greater than 0.2 i.e., series with strong or weak presumption of seasonality are excluded]. As shown in Table 7, there is no induced seasonality. This result is expected because X11 uses moving average filters and induced seasonality can be found in SEATS, which might use a seasonal filter for a nonseasonal series. (Hood 2002).

As indicated in sub-section A above, the IMF production system also performs a seasonal adjustment routine on series without seasonal pattern. The finding that X11 does not generate induced seasonality is encouraging but does not prevent the upfront exclusion of series without seasonal pattern.

Table 7: Percentage of series with absence of seasonality in the original series and seasonality in unadjusted series.

Type	IMF series without a zero value			IMF series with at least one zero value			Eurostat quarterly GHG emission series		
	#Series	Original	Adjusted	#Series	Original	Adjusted	#Series	Original	Adjusted
Overall	**646**	**17.5**	**0.0**	**1**	**3.7**	**0.0**	**217**	**18.1**	**0.0**
Economic series	633	18.3	0.0	1	12.5	0.0	206	17.8	0.0
Energy	*84*	*16.2*	*0.0*	*0*	*0.0*	*0.0*	*24*	*22.6*	*0.0*
External trade	*43*	*29.5*	*0.0*	-	-	-	-	-	-
Gross value added	*54*	*9.6*	*0.0*	-	-	-	*94*	*10.5*	*0.0*
Index of industrial production	*397*	*19.4*	*0.0*	*1*	*20.0*	*0.0*	*9*	*17.3*	*0.0*
Labor force	*3*	*8.6*	*0.0*	-	-	-	-	-	-
Price-adjusted turnover index	-	-	-	-	-	-	*1*	*4.0*	*0.0*
Transportation	*52*	*35.4*	*0.0*	*0*	*0.0*	*0.0*	-	-	-
Emissions and heating degree days series	13	5.3	0.0	0	0.0	0.0	11	26.2	0.0
Emissions	*10*	*20.0*	*0.0*	-	-	-	*11*	*73.3*	*0.0*
Heating degree Days	*3*	*1.5*	*0.0*	*0*	*0.0*	*0.0*	*0*	*0.0*	*0.0*
No predictor	-	-	-	-	-	-	*78*	*96.3*	*0.0*
p.value of proportion test		*0.000*	*0.000*		*0.218*	*0.000*		*0.000*	*0.000*

Source: ABS, BCEAO, BEA, EIA, Eurostat, IEA, IMF, OCDE, UNIDO and Authors' calculations.

Note:

#Series: Number of series with presumption of no seasonality in the original series	Original: Percentage of series with presumption of no seasonality (p.value greater than 0.2 or QS less than 3.2)	Adjusted: Percentage of series with presumption of seasonality in the adjusted (significance level of 5 percent or QS greater than 6)

F. DOES A MERE IMPLEMENTATION OF X11 SEASONAL ADJUSTMENT METHOD PRODUCE REASONABLE RESULTS?

This section examines whether a high-quality analysis using X11 from X13-ARIMA-SEATS can be performed without expert knowledge and without much experience in seasonal adjustment. The analysis is performed on a subset of time series with presumption of seasonality. On top of the use of a different seasonal adjustment method (the SEATS filter for instance), two interventions that would generate a discrepancy between adjusted estimates produced in this study and the ones collected from data providers include adjustment of calendar effects and the use of a multiplicative model.[12]

The range for deviation is acceptable and we are yet to investigate why the coincidence of quarter-to-quarter rate of change is lower than the acceptable coincidence of year-on-year rate of change.

The metrics are encouraging for the IMF production system given the limited time dedicated to seasonal adjustment.

Table 8: Metric for percentage error and coincidence between adjusted series by countries and automatic selection for X11.

Type	IMF series without a zero value				
	#Series	MAPE	RMSPE	q-to-q	y-on-y
Overall	**2 011**	**1.5**	**3.6**	**84.5**	**94.4**
Economic series	2 011	1.5	3.6	84.5	94.4
External trade	*89*	*4.9*	*5.8*	*84.1*	*93.9*
Gross value added	*485*	*0.7*	*1.6*	*86.8*	*96.4*
Index of industrial production	*1 437*	*1.5*	*3.9*	*83.8*	*93.7*

Source: ABS, IMF, OCDE, UNIDO, WTO and Authors' calculations.

Note:

#Series: number of original series with presumption of seasonality	MAPE: Mean Absolute Percentage Deviation	RMSPE: Root Mean Square Percentage Deviation	q-to-q: coincidence of quarter-to quarter rates of change	y-on-y: coincidence of year-on-year rates of change

V. Conclusion

In this study, we examine the performance of X11 with automatic model selection and no calendar adjustment across nine types of time series grouped into economic and emissions and heating degree days series (emissions, energy, external trade, gross value added, heating degree days, index of industrial production, labor force, price-adjusted turn-over and transportation). To control the effect of additional transformation on series, we divided the sub-annual series to produce global and regional quarterly GHG emissions into three datasets including the IMF series without a zero value, IMF series with at least one zero value and the Eurostat unadjusted quarterly GHG emission series. We develop six scenarios for each dataset to evaluate whether there are differences between the nine types of series based on proportion of series passing diagnostic tests or meeting quality control requirement, and metrics for percentage error and coincidence when comparing benchmarks and estimates. We found that:

- 78 percent of all types of time series are prone to seasonality and 90 percent display stable seasonality. The IMF can reduce the number of time series to seasonally adjust by one quarter, which might allow more analytical work to examine the diagnostic test and quality control for an acceptable number of series.
- The overall quality of seasonal adjustment is lower for emission and energy type series than other types of time series. The IMF should further review 200 series to better identify breaks and calendar effects.

[12] In this study, the multiplicative model is used for 60 percent of IMF series without zero value (59 percent for economic series and 67 percent for environmental series) and 72 percent for Eurostat quarterly GHG series (73 percent for economic series and 68 percent for environmental series).

- The airline model is selected as the final ARIMA model for 20 percent of time series with presumption of seasonality. The airline model and automatic modelling produce almost similar results, except for series with at least one zero value. Using the airline model in the IMF production system will reduce compilation time by one-third.
- There is no evidence that economic series are subject to more residual seasonality than emissions and heating degree days series. However, emissions and heating degree days series with at least one zero value display the highest proportion of series with residual seasonality and we think user's intervention and addressing calendar effects might reduce this proportion. Eventually, the evaluation of all M diagnostics to reduce the proportion of series displaying residual seasonality is desirable, but unrealistic in the IMF production system, which is a large-scale study.
- X11 does not generate induced seasonality, but this finding does not prevent the upfront exclusion of series without seasonal pattern in the IMF production system.
- X11 with automatic model selection as implemented in the current IMF production system produces acceptable results without expert knowledge and without much experience in seasonal adjustment.

To wrap up, though the overall quality of seasonal adjustment is lower for emissions and heating degree days type series, they can be seasonally adjusted–just like economic series– with X11, and the simple airline model. One reviewer suggested that the finding that the scenarios analyzed in this study yield similar but not exact outcomes when X11 seasonal adjustment method is applied to economic and emissions series aligns logically with certain geographical areas. This could be attributed to factors like early springs or unusually long summers, which can cause energy use to change from year to year, with only minimal implications for economic seasonality. We suggest that further research identifies seasonal factors that may influence emissions data, but not economic data. The IMF will continue to investigate the behavior of series with a zero value and will continue to exclude them from its production system. In a near future, this may pose a challenge if we user's intervention is required seasonally adjust emission series in a large-scale study considering the net zero emission target and for energy series used in policy making for energy transition. We have pursued this study based on proportion of series from automatic methods passing diagnostic tests or meeting quality control requirements with the knowledge that this does not imply a good seasonal adjustment, which requires the exhaustive knowledge of the series including the calendar effects and breaks not considered in this study. This requirement for exhaustive knowledge of series under analysis can only be met if data providers, and specifically countries allocate additional resources to produce seasonally adjusted series.

Annexes

A. OVERVIEW OF THE IMF'S METHODOLOGY TO PRODUCE QUARTERLY GHG EMISSIONS ACCOUNT.

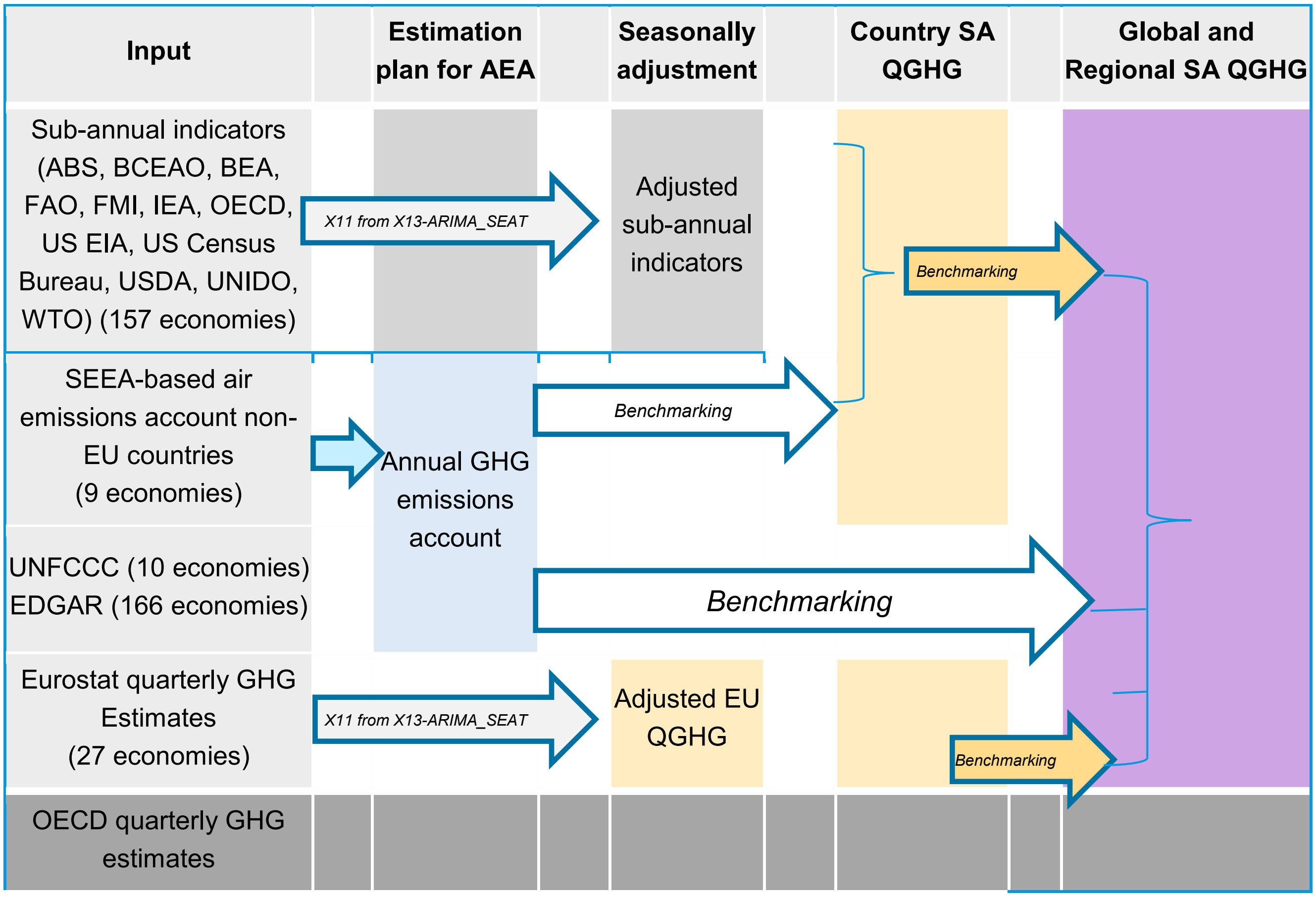
Quarterly GHG emissions accounts adopt the same principles, definitions, and structure as the annual air emissions account, as developed in the *Eurostat (2015) Manual for Air Emissions Account*. Air emissions account is one type of account developed in the *System of Environmental-Economic Accounts (SEEA)* to record human-induced emissions by resident economic units as classified by the International Standard Industrial Classification of All Economic Activities (ISIC) and by households. Major steps implemented by the IMF to prepare quarterly GHG are summarized in figure 2.

In the first step, the IMF prepares a database of annual SEEA-based GHG emissions account for 212 economies, which serve as the benchmark for the quarterly estimates. SEEA-based GHG emissions account is available for European Union members and nine non-European Union economies. For those economies that do not produce SEEA-based accounts, the IMF converts the United Nations Framework Convention on Climate Change's (UNFCCC) inventory data (for 10 economies) and Emissions Database for Global Atmospheric Research (EDGAR) inventory data (for 166 economies) into SEEA-based GHG emissions account using the *inventory-first* approach. The GHG emissions account can best be described as a four-dimensional data cube consisting of geography, GHG (carbon dioxide, methane, nitrous oxide and Fluorinated gases), activity (industries and households), and time. Since the level of detail by activity and GHG varies considerably across countries, an estimation plan is required to reduce all categories of these dimensions to a manageable number of time series. The IMF's estimation plan has a clustering of activities and gases. It targets the breakdown by industries and households, taking into consideration the relevance and availability of sub-annual predictors. The plan has three country groups that divide countries based on the availability of source data and the structure of their annual emissions account.

In the second step, the quarterly estimation technique for non-European Union countries follows the basic principle of temporal disaggregation as recommended in the *IMF (2017) Quarterly National Accounts Manual* to distribute the annual time series into quarterly values (backward series) and to extrapolate those quarters for which annual accounts are not yet available (forward series). Both distribution and extrapolation are performed with auxiliary information, that is, sub-annual (monthly or quarterly) "predictors" or "indicators," which are considered sufficiently suited to approximate the quarterly developments of GHG emissions. Sub-annual data are seasonally adjusted, either by the source or, if not, by the IMF. The IMF's adjustment also includes calendar effects whereby Easter and five Muslim moving holidays are parsimoniously included. For the 15 top emitting economies contributing to 56 percent of GHG emissions, the IMF combines qualitative and quantitative criteria to select their predictors. For the remaining 115 economies, the IMF selects their predictors based on their highest correlation. The *Denton proportional first difference variant method* is the preferred temporal disaggregation technique when the correlation coefficient for annual rates of change is the highest and the *Chow-Lin* static regression method is used otherwise. The quarterly estimates for 27 European Union countries are produced by Eurostat and seasonally adjusted by the IMF.

Finally, these seasonally adjusted quarterly GHG emissions account estimates at the country level are aggregated and benchmarked to annual world and regional GHG emissions using the *Denton proportional first difference variant method*. This last step is necessary because suitable sub-annual data are not available for all economies, the quarterly GHG emissions account estimates are available for only 157 economies, representing 97 percent of the world's GHG emissions.

Figure 2: Visualization of major steps to prepare IMF quarterly GHG emissions account



Source: IMF

Note:

Seasonal adjustment | *Seasonally adjusted indicators used in temporal disaggregation* | *Annual GHG account used in temporal disaggregation*

B. ADDITIONAL TABLES

Table 9: Emission share (percentage) of contributing type of series to the estimate of QGHG for 157 economies in the IMF

Region	Crops Livestock	Emissions	Energy	External Trade	Gross value added	Index of industrial production	Labor Force	Transportation	Total
Africa	1.18				0.23	4.43			5.84
Americas	0.43	11.11	3.68	0.79	4.22	2.35		0.02	22.6
Asia	7.39		32.66	0.68	2.14	11.78	0.12	0.25	55.03
Europe	0.18		4.87	0.09	1.18	7.9	0.13	0.8	15.15
Oceania	0.02		0.87	0.05	0.22	0.18	0	0.03	1.37
Total 157 economies	9.2	11.11	42.08	1.61	7.99	26.64	0.25	1.1	99.99

Source: IMF

Table 10: Emission share (percentage) of contributing type of indicators in Eurostat

Region	Degree Day	Emissions	Energy	Gross value added	Index of industrial production	Turnover Index	No predictor	Total
Total EU27	8.13	2.8	38.69	28.01	9.23	0.59	12.54	100

Source: Eurostat and Authors' calculations

Table 11: Quality control diagnostics of seasonal adjustment for X11 with airline model

Type	IMF series without a zero value			IMF series with at least one zero value			Eurostat quarterly GHG emission series		
	#Series	M7	QM2	#Series	M7	QM2	#Series	M7	QM2
Overall	**2 908**	**96.4**	**93.3**	**30**	**93.3**	**90.0**	**994**	**98.4**	**98.6**
Economic series	2 675	96.1	92.9	7	71.4	57.1	965	98.5	98.5
Energy	*412*	*94.9*	*89.6*	*2*	*50.0*	*50.0*	*76*	*100.0*	*97.4*
External trade	*94*	*98.9*	*90.4*	-	-	-	-	-	-
Gross value added	*492*	*97.4*	*95.9*	-	-	-	*821*	*98.3*	*98.7*
Index of industrial production	*1 559*	*95.7*	*92.8*	*4*	*75.0*	*50.0*	*40*	*100.0*	*100.0*
Labor force	*31*	*100.0*	*100.0*	-	-	-	-	-	-
Price-adjusted turnover index	-	-	-	-	-	-	*25*	*100.0*	*100.0*
Transportation	*87*	*97.7*	*94.3*	*1*	*100.0*	*100.0*	-	-	-
Emissions and heating degree days series	233	99.6	97.4	23	100.0	100.0	29	93.1	100.0
Emissions	*39*	*100.0*	*87.2*	-	-	-	*2*	*0.0*	*100.0*
Heating degree Days	*194*	*99.5*	*99.5*	*23*	*100.0*	*100.0*	*27*	*100.0*	*100.0*
No predictor	-	-	-	-	-	-	*3*	*100.0*	*66.7*
p.value of proportion test		*0.005*	*0.000*		*0.005*	*0.000*		*0.000*	*0.913*

Source: ABS, BCEAO, BEA, EIA, Eurostat, IEA, IMF, OCDE, UNIDO and Authors' calculations.

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