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Linkages between Energy Delivery and Economic Growth from the Point of View of Sustainable Development and Seaports

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Abstract: This paper presents the synchronisation of economic cycles of GDP and crude oil and oil products cargo volumes in major Polish seaports. On the one hand, this issue fits into the concept of sustainable development including decoupling; on the other hand, the synchronisation may be an early warning tool. Crude oil and oil products cargo volumes are a specific barometer that predicts the next economic cycle, especially as they are primary sources of energy production. The research study applies a number of TRAMO/SEATS methods, the Hodrick–Prescott filter, spectral analysis, correlation and cross-correlation function. Noteworthy is the modern approach of using synchronisation of economic cycles as a tool, which was described in the paper. According to the study results, the cyclical components of the cargo traffic and GDP were affected by the leakage of other short-term cycles. However, based on the cross-correlation, it was proved that changes in crude oil and oil products cargo volumes preceded changes in GDP by 1–3 quarters, which may be valuable information for decision-makers and economic development planners.

Keywords: cargo volumes; crude oil and oil products; economic cycles; economic management; decoupling; liquid bulk cargoes; maritime ports; seaports; sustainable development concept; synchronisation

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1. Introduction

1.1. Presentation of Research Problems

This study focuses on the synchronisation of economic cycles of gross domestic product (GDP) and crude oil and oil products cargo volumes in major Polish seaports (energy delivery; crude oil is the primary world source of energy production). It approaches economic cycle synchronisation as an early warning tool in economic management in the context of the sustainable development concept, which includes the paradigm of decoupling. While issues related to economic cycles and their synchronisation are quite common research problems addressed in the literature, the approach presented in this article is innovative, as no similar research study has thus far been completed on the basis of seaports. In this paper, crude oil and oil products cargo volumes are considered to be a leading indicator to predict the next economic cycle. Economic cycle synchronisation, in turn, is treated as an early warning tool for the purposes of economic management. The authors have emphasised the need to follow the assumptions of sustainable development along with decoupling and inclusive economy, watching out for any kinds of 'traps' related to treating GDP as the indicator of prosperity or to a pursuit of so-called 'wild' economic growth. The authors have taken an interdisciplinary approach to these issues, firstly, by presenting the genesis of and problems related to the concepts (theoretical approach); secondly, by referring to the academic achievements found in other papers or research studies (empirical and pragmatic approach) and thirdly, by combining the former and the latter in the form of policies, tools, strategies and types of measures (hybrid approach).

1.2. Organisation of the Paper

The research hypothesis was formulated as follows: synchronisation of economic cycles of GDP and crude oil cargo traffic volumes is significant from the point of view of economic management, and it constitutes an early warning tool. The purpose of this article is to identify economic cycles of GDP and primary energy sources such as crude oil and oil products cargo volumes. The study comprises major maritime ports with importance for the Polish economy (Gdańsk, Gdynia, Szczecin, Świnoujście and Police).

The paper consists of five sections. The first one is an introduction. Section 2 provides a literature review in the following four directions: (1) sustainable development including the concept of decoupling in relation to economic growth, (2) seaports as the integration factor of global economic system, (3) the concept of smart ports in the context of sustainable development and global economic system, (4) and the synchronisation of the economics cycles in the light of economic management and governance. In Section 3, the materials and methods used in the study are summarised. The next section contains the empirical results of the research conducted on the example of major Polish seaports. This section presents the decomposition of the variable that represents the main economic category of economy and the crude oil and oil products cargo volume using the TRAMO/SEATS method and then using the Hodrick–Prescott filter. This section also includes the results in the context of the synchronisation of cycles with optimal lags. At the end of the section the cross-correlation is shown, which is important from the point of view of an early warning system. The last section summarises the paper, discusses the empirical results and concludes the paper in the light of future research.

2. Literature Review

2.1. The Concept of Sustainable Development and Decoupling

Economic growth constitutes a priority for most countries that continuously take measures aimed at increasing their GDP. In most of the cases, economic growth means a rise in CO_2 emissions. The leading countries in terms of GDP volume and the top five emitters of CO_2 in 2018 were China, the USA, India, Russia and Japan [1]. In market economies, economic growth enables enterprises to make profits that are further invested in their development, thus leading to further economic growth and increased employment. Economic growth entails numerous problems related to the natural environment, which are addressed by the concept of sustainable development [2]. Hence, achieving economic goals in many cases is incompatible with implementation of the sustainability concept. It should be noted that treating GDP as a barometer for any country's general prosperity is not entirely justified [3,4], as there is a specific relation between economic growth and environmental issues: economic growth is accompanied by pollution growth; however, the increased pollution also constitutes a benefit for the economy, as new jobs are provided in order to eliminate the pollution effects [5].

In the 1980s, the so-called ecological economy was developed, which further evolved to become the sustainable economy. Later on, it was proposed that economic growth should focus not only on the economy but should be a complete macrosystem including the society and the environment [6]. The concept of sustainable development is not new. Its first precise definition may be found in the report of the UN's World Commission on Environment and Development (WCED) of 1987, entitled 'Our Common Future', also known as 'The Brundtland Report' after the Commission's chairman Gro Harlem Brundtland. The document aptly presented the idea of sustainable development and constituted a milestone in introducing and understanding the idea of sustainable development, also taking into account issues connected with transport [7]. It also stated that at the current level of civilisation, it is possible to have sustainable development, which means development that meets 'the needs of the present generation without compromising the ability of future generations to meet their own needs'. The report addressed three major areas that required an integration of measures, including economic growth and a balanced distribution of benefits; the conservation of natural resources and the environment; and social development [8].

As early as the 1980s, researchers started to pay attention to issues of sustainability, i.e., appropriate and conscious development of relations between social, economic and environmental issues [9,10]. Those three pillars are the basic ones, and more scientists put emphasis on culture as the fourth pillar. Culture, perceived as human identities, shape the environment in which we live and how it is perceived [11,12]. According to Hanley [13], the idea of sustainable development is broad, and it is defined in various ways, but in its essence, it boils down to provide a stable level of prosperity for future generations.

In 2015, the United Nations General Assembly adopted a resolution titled, 'Transforming our world: the 2030 Agenda for Sustainable Development' [14] containing the Sustainable Development Goals. These regarded achievements in five areas called the 5Ps: people, planet, prosperity, peace and partnership. The implementation of these goals and tasks was subject to evaluation by means of appropriate indexes [15]. Agenda 2030 is a universal document and requires adjusting to each country's realities (implementation of the Sustainable Development Goals, SDG) [16]; hence, the essential role is on the side of individual countries to meet those objectives [17].

The elements that distinguish the traditional economy from the sustainable economy are listed in the table below (Table 1).

Table 1. Differences between the traditional and sustainable economy.

	Traditional Economy	Sustainable Economy
Valued goods	Private goods	Private good, collective goods, factual
Main production factors	Labour, capital, information and technology	Natural resources, labour, capital, information and technology
Humans	*Homo economicus*	*Homo cooperativus*
Sustainability	Weak (strong and absolute anthropocentrism)	Strong (weak and relative anthropocentrism)
Means to achieve global prosperity	Free trade, acceptance of currently functioning institutions and structures of world trade	Fair system of global economy with social and ecological minimum standards and charges for using global environmental goods

Source: Ganowicz-Bączyk, A. Ekonomia w Służbie Zrównoważonego Rozwoju. *Studia Ecol. Bioethicae UKSW* **2013**, *11*, 36 [18].

To a certain extent, the sustainable economy stands in opposition to the traditional economy, accounting for a wider range of issues, also those referring to social and environmental problems (the need to protect ecosystems for ethical reasons, e.g., ecocentrism) [18,19]. Sustainable development is strongly connected to economic growth and related with environmental protection and social inclusion [20–22]. Hence, there is a need for an inclusive economy [23], understood in terms of including all resources [24]. Initially, measures taken with regard to sustainable development were limited mainly to the need to reduce [25] the negative impacts of economies on the natural environment. Over time, the concept gained importance and entered the mainstream of discussions on social and economic development, at the same time becoming a horizontal principle reflected at the level of both individual countries and the whole European Community.

Economic growth is the goal of economic policy due to its positive consequences for the growth of social welfare, improvement of the competitive position in the world economy and the development of innovation. In the light of the theory of sustainable development, it has been noticed that economic growth, due to the excessive use of resources, also becomes a source of undesirable phenomena. This issue was reflected in the concept of decoupling. Its essence is to decouple economic growth from resource intensity.

Decoupling as a theoretical concept appeared in Western European literature in the mid-nineties of the last century [26] and was developed in relation to the transport intensity of the economy [27]. Model approaches to decoupling were proposed by Tapio [28], and the connection of this concept with environmental protection by Zhang [29]. The first political references to decoupling are contained in the following two documents from 2001: A European Union Strategy for Sustainable Development [30] and The OECD Environmental Strategy for the First decade of 21st Century [31]. The first document describes 'decoupling environmental degradation and resource consumption from economic and social development', the second defines decoupling as 'breaking the link' between 'environmental bads' and 'economic goods'. Decoupling, understood as 'a determined breaking the link between transport growth and gross domestic product growth in order to reduce pollution and other negative side-effects of transport development', has become the paradigm of EU transport policy [32]. Initially, it was aimed at reducing the volume of transport by modifying the economic and social factors generating those with transport origin (consumption, production, location). However, along with the new global approach to the existing resources efficient usage (first decade of the 21st century), it was modified to separate economic growth from the increase in the negative environmental effects caused by transport. The current understanding of decoupling means 'such a reconstruction of economic relations that enables the decoupling of economic growth from the rate of consumption of scarce natural resources and environmental degradation' [33]. Action in this order requires attention, both to the volume of resource use in connection with economic activity, and to the environmental effects associated with their use at all stages of the life cycle [34]. Practical guidelines for measuring the progress in decoupling have been prepared by the OECD [35]. Research shows that countries with policy frameworks that are more supportive of renewable energy and of climate change tend to decouple the emissions trend from GDP more closely, and for both production- and consumption-based emissions [36].

As for transport, which has a particular impact on the natural environment and that, due to its very nature, should meet the sustainability requirements, it is possible to notice some concrete measures taken in that regard [37]. Transport focuses on the sustainable development goals [38] that relate mainly to energy consumption, alternative sources of energy and pollution reduction technologies [39,40]. In the case of maritime transport, these measures predominantly include air and water pollution, with a particular focus on terminal operations and vessel handling at ports.

Maritime transport constitutes an important link in global transport chains and plays a key role in regional economies. Nevertheless, the activity of seaports is connected with environmental impacts, mainly resulting from works performed within the port as such (transport, transhipment, storage) [41]. Thus, economic growth related to seaport operations must meet the requirements of environmental protection and social development, in line with the principles of sustainable development [42,43]. In view of the significance of seaports and their role of nodes in global supply chains, measures taken by them to implement the idea of sustainable development and functioning are particularly important. They also have an impact on the functioning of other entities being part of the chain. The concept of Green Ports is defined as 'a product of a long-term strategy for sustainable and environmentally-friendly development of port infrastructure' [44,45]. The functioning of 'green ports' focuses mainly on the aspects related to the environment and climate changes, which further then relate to the aforementioned Agenda 2030 published by the UN. Additionally, the importance of seaports in global trade is directly related to the GDP of the countries that make use of the seaports [46].

2.2. Seaports as a Major Element of Integration in Global Economic System

Over the past few decades, the definition of a maritime port has been evolving, starting from a facility for handling transoceanic vessels in international trade, to viewing it as a logistics platform in relation to the trans-European complex and basal network [47]. Seaports are one of the major elements of the general transport sector and are currently connected with the developing global economy [48–52]. In the academic literature, seaports are described as means of integration with the global economic system [53]. Seaports evolve and harmonise with social and economic changes, also adapting to technical and technological advancements.

In Poland, seaports are regulated by the provisions of the Act of 20 December 1996 on maritime ports and harbours [54]. It defines a maritime port or harbour 'as the port basins and grounds as well as the related port infrastructure located on the premises of the maritime port or harbour' and introduces the concept of 'a maritime port of primary significance for the national economy'. In Poland there are four such seaports, i.e., those located in Gdańsk, Gdynia, Szczecin and Świnoujście. They are managed by the following three companies, respectively: Zarząd Morskiego Portu Gdańsk S.A., Zarząd Morskiego Portu Gdynia S.A. and Zarząd Morskich Portów Szczecin i Świnoujście S.A. [55].

In 1994, the United Nations Conference on Trade and Development attempted to categorise maritime ports by means of the so-called UNCTAD model. It divides maritime ports into the following three generations in respective periods: prior to 1960, from 1960 to 1980, and after 1980. The following criteria were applied in preparing the classification: main types of cargoes, attitude to and strategies of seaport development, scope of activities, characteristics of the organisation and products, decision-making factors [56]. The attempts at port classification, presented in the academic literature, result from their complexity and heterogeneity ('<<Fourth-generation ports>> which are physically separated but linked through common operators or through a common administration' [57]) [57,58]. The three-generation port model was critically evaluated by the WORKPORT project team financed by the European Union in the years 1998–1999. The main goal of the WORKPORT project was to identify the impact of new technologies applied in ports on their work environments [59]. The WORKPORT consortium rejected the idea found in the UNCTAD model (United Nations Conference on Trade and Development model), according to which the evolution process can be best described in the categories of subsequent port generations, where each category has its own, well-defined set of characteristics [60]. The evidence resulting from the study proves that seaports evolve continuously, adapting to new technologies, new regulations, changed work practices and other impacts, depending on the needs. Moreover, it was proven that several evolution streams may be observed simultaneously, and the rate of changes in each of them may be considerably diverse [61]. This model ignored factors such as port size, geographical location and the extent of public and private sector engagement in investment activities. Undoubtedly, the evolution of ports and their further categorisation were affected by factors such as mechanisation and automation; containerisation; investments in the infrastructure, suprastructure and IT systems; systems to support cargo and information handling; labour culture; occupational health and safety; environment; the computerisation of ports; provision of training and taking care of improving the organisational culture [56,62]. In contrary to the UNCTAD model, the WORKPORT model put emphasis on working cultures, health and safety and increasing the awareness of the environment [60].

Based on the Polish and other academic literature on the subject, Kaliszewski presented models of the fifth and sixth generation ports. The quoted authors include Lee and Lam [62]; according to their hierarchisation, a fifth-generation port is characterised by a greater complexity and greater possibilities of creating added value, compared to ports of previous generations. It is also important that fifth-generation ports develop their strategies and solve problems of local communities in a way that ensures sustainable development; the port of Singapore is provided as an example. Even though the sixth generation of ports has been outlined, no port in the world met its criteria by 2017.

2.3. A 'Smart Port' Concept

Nowadays, the more and more discussed concept is that of a 'smart port'. In relation to this concept, there are legal regulations based on provisions derived from the United Nations Conference on Trade and Development (UNCTAD), the International Maritime Organisation (IMO, London, UK), and the European Union (EU) (The Motorways of the Sea Digital Multi-Channel Platform, 2015) [63]. Quoting Molavi et al., the regulations are aimed at improving the sustainable character of ports, motivating them to implement new technologies and ensure standards for evaluating ports' efficiency. There is no official, uniform definition of 'smart ports'. The studies completed by Molavi et al. outline the smart port concept and present a quantitative evaluator—the smart port index. A smart port attracts better educated people, a qualified workforce, smart infrastructure and automation in order to facilitate development and knowledge-sharing, the optimisation of port operations, increasing the port's resilience, ensuring sustainable development and guaranteeing security and safe operations. A smart port comprises the following four major areas of activity: operations, environment, energy and safety and security.

The 'smart port' concept derives from and is fully integrated with the concept of the 'smart city' [63–65]. González et al. point out that the study presented by Molavi et al. ignored one of the pillars of a 'smart port'—the social aspect. According to some researchers [65], a smart port must be designed for citizens and by citizens, putting them in the centre of the future port. Therefore, a port must be sustainably integrated with the city or the environment, ensuring space that can be used by inhabitants, promoting its relation with the sea and making it possible to make use of it. The authors presented the concept in a way that is easy to understand. A smart port is based on the application of new technologies to transform port services into interactive and dynamic services that are more efficient and transparent. Its goal is to meet the needs and requirements of customers and users. Moreover, from the point of view of environmental protection, the sustainable development of a port constitutes its fundamental pillar as well as its orientation to the city and its citizens in order to ensure high quality of the space and the services. The new technologies that are being considered include artificial intelligence (AI), Blockchain, and the Internet of Things (IoT) [66].

On the basis of the quantitative studies based on the example of 14 seaports (Hamburg, Rotterdam, Antwerp, Busan, Singapore, Los Angeles, Vancouver, Jebel Ali, New York and New Jersey, Houston, Shanghai, Tanjung Priok, Jeddah, Hong Kong), Molavi et al. observed a positive correlation between the value of the SPI (Smart Port Index) and GDP per capita of the given country. This means that seaports located in richer countries show higher SPI values. Moreover, they found a positive correlation between the national spending on R&D (Research and Development) per capita and the port's SPI value, which they explained as follows: when a country is more open to innovations and higher education systems, seaports in that country are more interested in implementing new technologies and taking an innovative approach. A negative correlation, in turn, was found between the country's energy consumption per GDP and the SPI. The higher values of energy intensity show that production and services require greater industrial efficiency and more effort. This means that the country's industry is not productive or energy efficient.

The smart port concept was also presented as an extension of the UNCTAD model to describe a fifth-generation port (Table 2). The cut-off dates to distinguish between the generations have been a problem to researchers since the very beginning. In the table below, fourth- and fifth-generation ports are dated, respectively, from 2000 and 2020, whereas the quoted studies of Molavi et al. date the generations 10 years earlier.

Table 2. UNCTAD Smart Port Model.

1st Generation	2nd Generation	3rd Generation	4th Generation	5th Generation
1940	**1960**	**1980**	**2000**	**2020**
Mechanic Port	Container Port	EDI Port	Internet Port	Smart Port
Mechanical operation	Free Zone	International network	Global network	ITS port
Handicraft works	Industrial area	Integrated centre	Port community	Logistic community
	Free tax port	Commercial area	Logistic area	Smart city
		EDI services	Intermodal services	Smart Hinterland
			Internet services	Multimodal services
				Sustainable port

Source: https://www.onthemosway.eu/wp-content/uploads/2015/07/Seaports-development-v-2.0.pdf [47] (accessed on 13 November 2020).

2.4. Economic Cycles and Their Synchronisation for Economic Management

The studies conducted by the aforementioned researchers fall within the areas of economic management and governance. They are particularly important from the point of view of seaports [67–71]. On the one hand, it is possible to refer to a global approach with its underlying world order and its legal and economic consequences, on the other—to focus on the national level from the point of view of the country's development in the context of global trends, or to think of it as of economic management on a microscale, i.e., at the level of the ports themselves [72–74]. The concept of governance, as opposed to economic management, has a broader meaning; it can also be considered in interdisciplinary terms. In relation to ports, the term 'governance' relates to multi-directional relationships between the multi-layer management on the global, national and local level in the legal, economic, environmental and social governance. The main components of port governance are governmental organisations, port organisations, institutional arrangements, port regulatory and managerial and operating activities; the directional relationships between them answer the question who controls and who interacts; its effects are goals that may be measured by means of tools, i.e., effectiveness or efficiency [70,75].

The latter concept pertains to economic management exclusively on one of the levels in relation to the socio-economic policy aspects. On the one hand, it regards the management of financial, human and material resources, i.a., focusing on issues related to multi-speed Europe [76]. On the other hand, it pertains to any given entity's economic and financial management [67]. One of the tools of economic management (apart from the ones mentioned above in the context of port evolution) is the analysis of economic cycles and their synchronisation [77–80]. Cycles are one of the basic elements of the early warning system/model in case of crisis situations [81]. In addition to the analysis of the irregular element (shock impulse), trend (economy drifting) and the cycles overlapping (leakage effect), the cycle analysis is also interesting in terms of forming a positive or negative output gap [82]. Moreover, maritime ports, and more specifically cargo volumes (particularly crude oil) in the ports, are deemed to be the barometer of the Polish economy [83,84]. For that reason, the further parts of this paper present studies based on economic cycles for GDP (representing economic growth) and for crude oil and oil products cargo volumes (representing the economic, environmental and governance aspects).

3. Data and Methods

The research study was based on secondary data. The figures for monthly crude oil and oil products cargo volumes (thousand tonnes) were obtained from the Statistical Yearbooks of Maritime Economy [85–91] (the data are presented in Table 3), whereas the figures for the Gross Domestic Product (PLN billion, at constant prices) were derived from the OECD statistics database [92] (the data are shown in Table 4). The monthly crude oil and oil products cargo volumes were aggregated via summing up the figures to obtain quarterly values (Table 4). The analysis was based on quarterly data and covered the 2012–2018 period. The choice of the time scope was dictated by procedural premises due to analysing short-term cycles in the nearest time perspective (the 2018 data were the latest data available).

Based on Tables 3 and 4, it is possible to surmise that the data are characterised by seasonality and show a growth pattern. However, a detailed analysis will be presented further on in this paper.

The authors used Gretl software with TRAMO/SEATS packages. The data were analysed by means of a few methods. The first of them, the TRAMO/SEATS (Time series Regression with ARIMA noise, Missing observations and Outliers/Signal Extraction in ARIMA Time Series) method was applied to seasonally adjust the data, and to decompose them into trend-cycle and irregular (shock) components. Those 3 components summarised together are equal to the original data. The time-series model plus seasonal adjustment estimated. The critical value for outliers set on the threshold, which was equal to 3.3 (it is universal value). Parameters set to detect and correct for outliers besides additive outliers, allowed for transitory changes and shifts of level. In transformation, the mean correction in automatic form was used (optimal choice between log transformation and no log transformation). The ARIMA parameters were non-seasonal differences equal to 1, seasonal differences equal to 1, non-seasonal AR terms equal to 0, seasonal AR terms equal to 0, non-seasonal MA terms equal 1, seasonal MA terms equal to 1.

Table 3. Monthly crude oil and oil products cargo volumes in major Polish seaports (k tonnes).

Month	2012	2013	2014	2015	2016	2017	2018
January	562.8	1477.2	1191.6	1264.7	1327.8	1640.2	1716.3
February	506.8	1149.8	1031.8	1166.4	1352.0	1567.1	1804.3
March	797	891.1	1281.4	1442.5	894.8	1392.8	1985.6
April	796.8	321	1512.4	920.6	1444.8	1252.9	2005.0
May	534.9	610.8	681.4	1427.4	1159.7	1556.2	1499.1
June	507.5	858.8	767.4	1821.6	1004.6	1534.5	1399.2
July	1092.9	1079.6	759.8	1300.3	1472.1	1199.6	1551.8
August	1153.5	1172.8	1234.3	1744.2	1711.9	1551.7	1500.1
September	1634.2	1551.9	1281.7	1507.2	1886.8	1215.1	1405.1
October	1525	1312.2	1577.5	1340.6	1322.3	1656.7	1767.6
November	1908	1136.3	1302.3	1285.2	1480.1	1445.3	2028.4
December	1303	1177.7	1506.9	1473.2	1705.0	2306.3	1442.1

Source: own work based on data obtained from the Statistical Yearbooks of Maritime Economy [85–91].

Table 4. Quarterly crude oil and oil products cargo volumes (in k tonnes) in major Polish seaports and quarterly GDP figures (in PLN bln at constant prices).

	Crude Oil and Oil Products Cargo Volumes						
Quarter	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Q1	1866.6	3518.1	3504.8	3873.6	3574.6	4600.1	5506.2
Q2	1839.2	1790.6	2961.2	4169.6	3609.1	4343.6	4903.3
Q3	3880.6	3804.3	3275.8	4551.7	5070.8	3966.4	4457.0
Q4	4736.0	3626.2	4386.7	4099.0	4507.4	5408.3	5238.1
	Gross Domestic Product						
Quarter	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Q1	413.50	412.41	425.47	442.94	456.34	478.60	503.15
Q2	412.49	416.85	430.32	446.43	462.33	482.83	509.85
Q3	414.30	420.01	433.92	452.09	463.51	488.26	516.88
Q4	412.11	421.12	436.73	457.64	474.00	496.58	520.82

In the table, the GDP is in PLN bln at constant prices. For comparison purposes, the authors have included the weighted average exchange rate from the National Bank of Poland for 2018: EUR/PLN equal to 4.2623 (EUR 1 = PLN 4.2623) and USD/PLN equal to 3.6134 (USD 1 = PLN 3.6134) [93]. Source: own work based on data obtained from the Statistical Yearbooks of Maritime Economy [85–91] and the OECD statistics database [92].

The second step was to apply the Hodrick–Prescott filter (with smoothing parameter λ = 1600), as this is one of the best filters for a time series of this type. As a result of the filtration, it was possible to decompose trend, cycle and shock by using the following formula by the minimisation problem [94,95]:

$$\min_{\tau_t}\left\{\sum_{t=1}^{T}(y_t-\tau_t)^2+\lambda\sum_{t=2}^{T-1}[(\tau_{t+1}-\tau_t)-(\tau_t-\tau_{t-1})]^2\right\} \tag{1}$$

where:

$$y_t = \tau_t + c_t + \epsilon_t \tag{2}$$

T is the number of observations;
t is the index of time, $t = 1, 2, \ldots, T$;
λ is the smoothing parameter;

τ_t is the smoothed series, trend;
y_t is the input series: decompose into trend, cycle and shock;
c_t is the cycle, cyclical component;
ϵ_t is the shock, irregular component.

The first term in the loss function imposes a specific penalty for the variance of cycle (c_t), while the second term imposes a specific penalty for the lack of smoothed trend (in τ_t).

Figure 1 presents an original proposal for framework of the methodology.

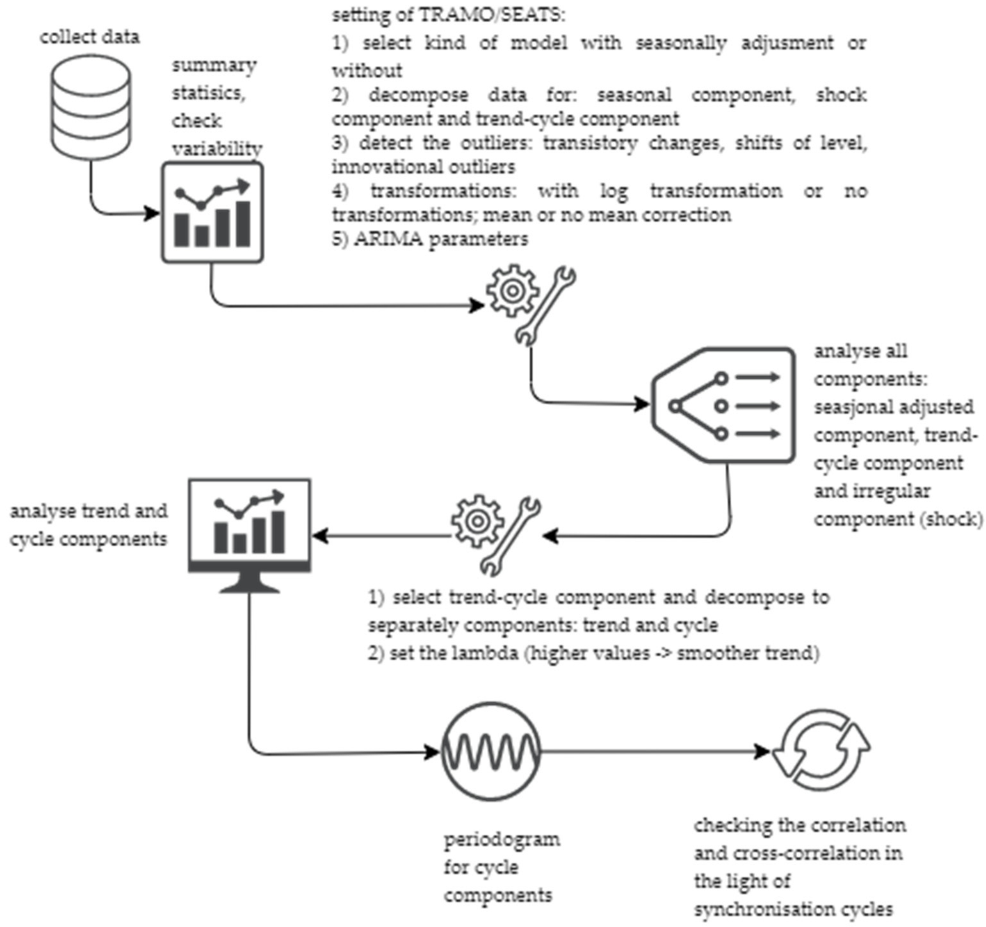

Figure 1. An original proposal for a framework. Source: own elaboration.

In the next step, correlation and spectral analyses were applied to the cycles.

The following representative variables were adopted:

- GDP—Gross Domestic Product (raw data in bln PLN, at constant prices)
- CTCO—cargo traffic of crude oil and oil products (k tonnes)
- GDP_sa—seasonally adjusted GDP (estimated using TRAMO/SEATS)
- GDP_trcl—trend/cycle for GDP (estimated using TRAMO/SEATS)
- GDP_sh—irregular/shock component for GDP (estimated using TRAMO/SEATS)
- GDP_tr—trend for GDP (filtered using the Hodrick–Prescott filter)
- GDP_cl—cycle for GDP (filtered using the Hodrick–Prescott filter)
- CTCO_sa—seasonally adjusted CTCO (estimated using the TRAMO/SEATS)
- CTCO_trcl—trend/cycle for CTCO (estimated using the TRAMO/SEATS)
- CTCO_sh—irregular/shock component for CTCO (estimated using the TRAMO/SEATS)
- CTCO_tr—trend for CTCO (filtered using the Hodrick–Prescott filter)
- CTCO_cl—cycle for CTCO (filtered using the Hodrick–Prescott filter)

4. Empirical Results

Table 5 presents the basic descriptive statistics for GDP and CTCO.

Table 5. Summary statistics, using the observations 2012: 1–2018: 4 (quarterly data).

Variable	Time Range	Mean	Standard Deviation	Coefficient of Variation	Minimum	Maximum	Skewness	Excess Kurtosis
CTCO (k tonnes)	all	3966.75	989.22	0.2494	1790.6	5506.2	−0.7284	0.1842
GDP (PLN bln)	all	453.63	35.09	0.0774	412.11	520.82	0.4534	−1.0336
CTCO (k tonnes)	2012	3080.60	1460.00	0.4740	1839.20	4736.00	0.1665	−1.7808
GDP (PLN bln)	2012	413.10	0.99	0.0024	412.11	414.30	0.2341	−1.5346
CTCO (k tonnes)	2013	3184.80	936.93	0.2942	1790.60	3804.30	−1.0994	−0.7069
GDP (PLN bln)	2013	417.60	3.9044	0.0093	412.41	421.12	−0.5335	−1.2513
CTCO (k tonnes)	2014	3532.10	611.75	0.1732	2961.20	4386.70	0.7080	−0.9566
GDP (PLN bln)	2014	431.61	4.86	0.0113	425.47	436.73	−0.2911	−1.2986
CTCO (k tonnes)	2015	4173.50	281.98	0.0676	3873.60	4551.70	0.4588	−0.9908
GDP (PLN bln)	2015	449.77	6.46	0.0144	442.94	457.64	0.2046	−1.4250
CTCO (k tonnes)	2016	4190.50	728.63	0.1739	3574.60	5070.80	0.2825	−1.6301
GDP (PLN bln)	2016	464.05	7.34	0.0158	456.34	474.00	0.5103	−0.9567
CTCO (k tonnes)	2017	4579.60	610.70	0.1334	3966.40	5408.30	0.5499	−1.0314
GDP (PLN bln)	2017	486.57	7.76	0.0159	478.60	496.58	0.3717	−1.2479
CTCO (k tonnes)	2018	5026.10	452.55	0.0900	4457.00	5506.20	−0.2744	−1.3015
GDP (PLN bln)	2018	512.68	7.81	0.0152	503.15	520.82	−0.2200	−1.4421

Mean was computed by formula: quotient of the sum of all data points for each variable and number of data points. Standard deviation is a square root of the variance. Variance is the quotient of two values. The first value is the sum of all squared differences between the data point and mean. The second value of the quotient is the number of data points minus 1. Coefficient of variation is the quotient standard deviation and mean. Minimum is the lowest value. Maximum is the highest value. Skewness is a measure of asymmetry; it presents its distortion from the normal distribution for a given data set or a symmetrical bell-shaped curve. It is quotient of the sample third central moment and the cube of the sample standard deviation. Excess kurtosis is a kurtosis minus 3. It compares the kurtosis coefficient with the normal distribution coefficient. Its interpretations may vary. If positive, it represents the leptokurtic distribution, if negative—the platykurtic distribution, if the value is equal to or nearly equal to zero—the mesokurtic distribution. It is a very good indicator for early warning, indicating sensitivity to extreme values. It can be expressed as the quotient of the fourth central moment and the standard deviation to the fourth power, the value of the result minus 3; also, as the quotient of the fourth sample moment about the mean and square of the second moment about the mean, value of the result minus 3. Source: own computations in Gretl software based on Table 4.

As it can be derived from Table 5, more variation is shown by the CTCO variable (the coefficient of variation at the level of 24.94%) compared to GDP (7.74%). The coefficient of variation indicates the share of the standard deviation in the mean. The variables vary in terms of quarterly variation, which may be caused by cycle variability, seasonality or shocks.

Figures 2 and 3 show the frequency distribution for CTCO and GDP (histograms). It can be assumed that they have a normal or close to normal distribution (no grounds to reject the null hypothesis, that they have a normal distribution, because the *p*-value is greater than 0.05). The same conclusion was drawn from the analysis of the statistical results to test the normality of the distribution using the Doornik–Hansen test, Shapiro–Wilk W, Lilliefors test and Jarque–Bera test (Table 6).

Table 6. Tests for normality for CTCO and GDP, using the observations 2012: 1–2018: 4.

Test for Normality	CTCO	GDP
Doornik–Hansen test	3.1404 [0.2080]	5.0893 [0.0785]
Shapiro–Wilk W	0.9306 [0.0639]	0.9174 [0.0299]
Lilliefors test	0.1417 [~=0.15]	0.1184 [~=0.39]
Jarque–Bera test	2.5158 [0.2843]	2.2056 [0.3319]

The *p*-values are in square brackets s; threshold *p*-value < 0.05. We could only reject null hypothesis about normality in Shapiro–Wilk W test for GDP, because *p*-value < 0.05. Source: own computation in Gretl based on Table 4.

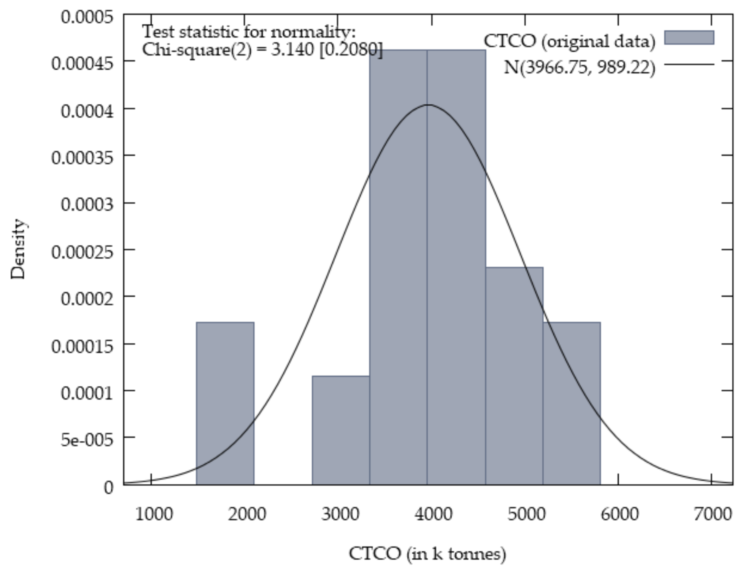

Figure 2. Frequency distribution for CTCO. Test for null hypothesis of normal distribution: Chi-square (2) = 3.140 with *p*-value = 0.2080; threshold *p*-value < 0.05; number of bins = 7, mean = 3966.75, sd = 989.22. Source: own computation in Gretl software based on Table 4.

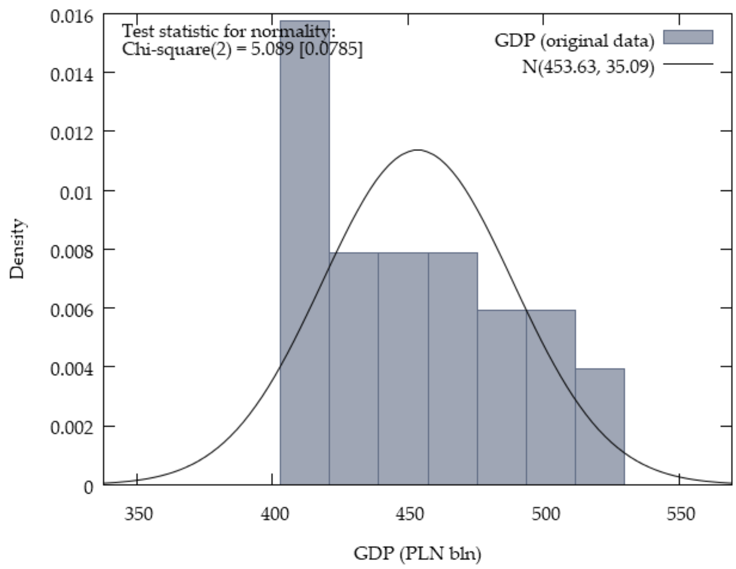

Figure 3. Frequency distribution for GDP. Test for null hypothesis of normal distribution: Chi-square (2) = 5.089 with *p*-value = 0.0785; threshold *p*-value < 0.05; number of bins = 7, mean = 453.63, sd = 35.09. Source: own computation in Gretl software based on Table 4.

Table 7 presents the results for the occurrence of the unit root (non-stationarity). The time series up to and including the fourth order of delay are non-stationary, which implied the need to transform (d = 1, first differences) the series in the TRAMO/SEATS method (see Appendix A, Tables A1 and A2).

Figures 4 and 5 present decomposed CTCO and GDP raw time series, following the seasonal adjustment for the shock component and trend-cycle component.

The data analysis has shown that CTCO was characterised by seasonality, whereas GDP showed small seasonal adjustments. What is worth noting is that the trend-cycle component of GDP reflected the raw data, while the decomposed CTCO became a totally new constituent, which is interesting from the point of view of the analysis. As for the shock component, it was found that in the case of CTCO, the shock impulses were stronger than for GDP; however, in the case of GDP, these were more frequent.

Table 7. Tests for unit root existing for CTCO and GDP with optimal number of lag, using the observations 2012: 1–2018: 4.

Unit Root Test	CTCO	GDP
Augmented Dickey–Fuller test	1.3817 [0.9587]	3.1662 [0.9997]
Kwiatkowski–Phillips–Schmidt–Shin test	0.7775 [<0.01]	0.6574 [0.0190]
Fractional integration	Local Whittle Estimator: z = 2.8007 [0.0051] /estimated degree of integration = 0.8085 (0.2887)/ GPH test: t(1) = 3.4814 [0.1781] /estimated degree of integration = 0.8286 (0.2380)/	Local Whittle Estimator: z = 4.1888 [0.0000] /estimated degree of integration = 1.0472 (0.2500)/ GPH test: t(2) = 30.4587 [0.0011] /estimated degree of integration = 1.0695 (0.0351)/

Optimal lag for Augmented Dickey–Fuller test is equal to 3 for CTCO and equal 4 for GDP; max was 4, criterion modified AIC. In square brackets is p-value; threshold p-value < 0.05. In normal brackets is standard deviation. Note that z and t(1) or t(2) in fractional integration are test statistics. Null hypothesis in the Kwiatkowski–Phillips–Schmidt–Shin test is opposite to null hypothesis in the Augmented Dickey–Fuller test. Null hypothesis in the Kwiatkowski–Phillips–Schmidt–Shin test is that time series are stationary (alternative: they are non-stationary). Null hypothesis in Augmented Dickey–Fuller test is that the time series are non-stationary (alternative: they are stationary). In fractional integration, if test statistics are close to 1 it means that the time series are non-stationary, if close to 0—they are stationary. Source: own computation in Gretl software based on Table 4.

Figure 6 shows the seasonal fluctuations for CTCO and GDP. The seasonal fluctuations for CTCO decrease with time (lower amplitudes).

Figures 7 and 8 present on separate graphs the trend and the cycle components of the GDP and CTCO variables (filtration using the Hodrick–Prescott filter).

It follows from the analysis of Figures 7 and 8 that both variables showed a steady upward trend. However, the core of the analysis is the cycles. It should be noted that cycles are measured from one trough (depression) to another trough (depression). Based on the graphic analysis of the cycle, it can be concluded that there was at least one cycle for CTCO, and at least two cycles for GDP. In the case of CTCO, the highest cycle peak was seen in the fourth quarter of 2012, while the lowest cycle trough was identified in the first quarter of 2014. As for GDP, the highest cycle peak was seen in the first quarter of 2012, and the lowest depression in the second quarter of 2016.

To address a supposition that the cycles were not synchronised, a Pearson's correlation analysis (Table 8) and a spectral analysis (Figure 9) were immediately carried out.

Table 8 presents the Pearson correlation coefficients aimed at evaluating the correlation between the GDP and CTCO cycles.

Table 8. Correlation coefficients, using the observations 2012: 1–2018: 4.

GDP_cl	CTCO_cl	
1.0000	0.2757	GDP_cl
	1.0000	CTCO_cl

5% critical value (two-tailed) = 0.3739 for n = 28. On the main diagonal of the correlation matrix there is always the value 1 (the variable is correlated 100% with itself); if the correlation coefficient is higher than the 5% critical value, then such a coefficient is considered statistically significant. Source: own computation in Gretl software based on Table 4.

As seen in Table 8, it is not possible to confirm a statistically significant correlation between the GDP and CTCO cycles, as the correlation coefficient amounting to 0.2757 was lower than the value of the two-tailed rejection region (critical value) of 5% (0.3739). There is no reason to interpret the correlation coefficient between CTCO_cl and GDP_cl (equal to 0.2757), as this correlation was not confirmed to be statistically significant (it may be apparent).

In view of this fact, a spectral analysis was applied for the GDP and CTCO cycles (Figure 9).

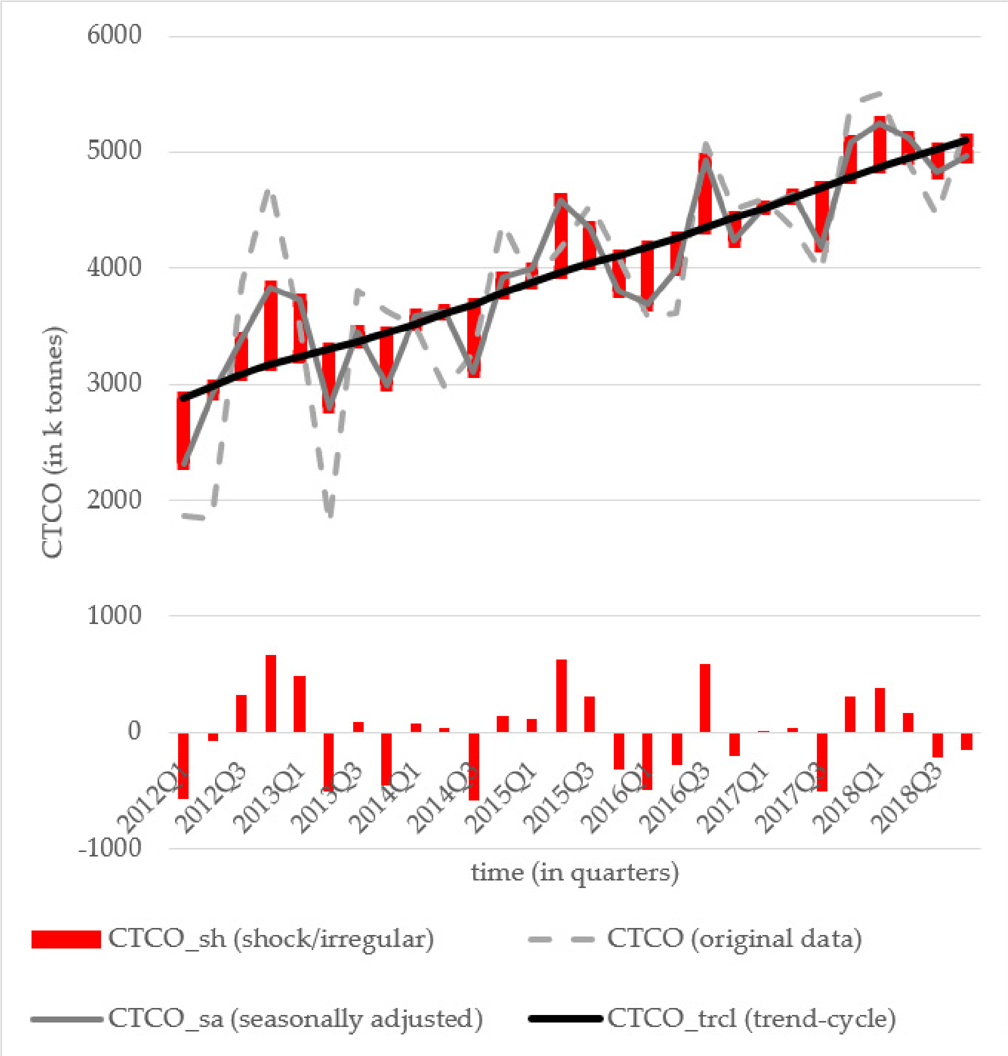

Figure 4. Decomposition of CTCO into components by means of the TRAMO/SEATS method (in k tonnes). CTCO_sh is calculated as difference between CTCO_sa and CTCO_trcl. In the figure, this is shown two times (as difference and as absolute value). Source: own computation in Gretl software with TRAMO/SEATS packages based on data obtained from the Statistical Yearbooks of Maritime Economy [85–91].

It follows from Figure 9 that in both the CTCO cycle and the GDP cycle, a leakage effect can be observed, i.e., cycles of various lengths and speeds are overlapping. Thus, a simple immediate synchronisation did not reveal a correlation between the cycle phases.

Based on the spectral density analysis, it was found that CTCO was characterised by three cycle types (the first lasted 9.33 quarters, the second—3.11 quarters, the third—2.33 quarters). The spectral density analysis carried out for GDP identified the first cycle duration of 7 quarters, the second cycle—4.67 quarters, the third—3.11 quarters, the fourth—2.80 quarters. Thus, the supposition was confirmed, i.e., the cyclic component of CTCO and GDP were different, and their synchronisation should take into account the time lag.

In view of the observations, the cross-correlation function was computed, taking into account the lags (maximum lag: four quarters) (Figure 10). Along with that, it is important to note, that this type of recognition of the economic cycle phases plays a significant role in sustainable development, in terms of efficiency and the balanced distribution of benefits.

An extension of the above test results is included in Appendix A (Tables A1–A4).

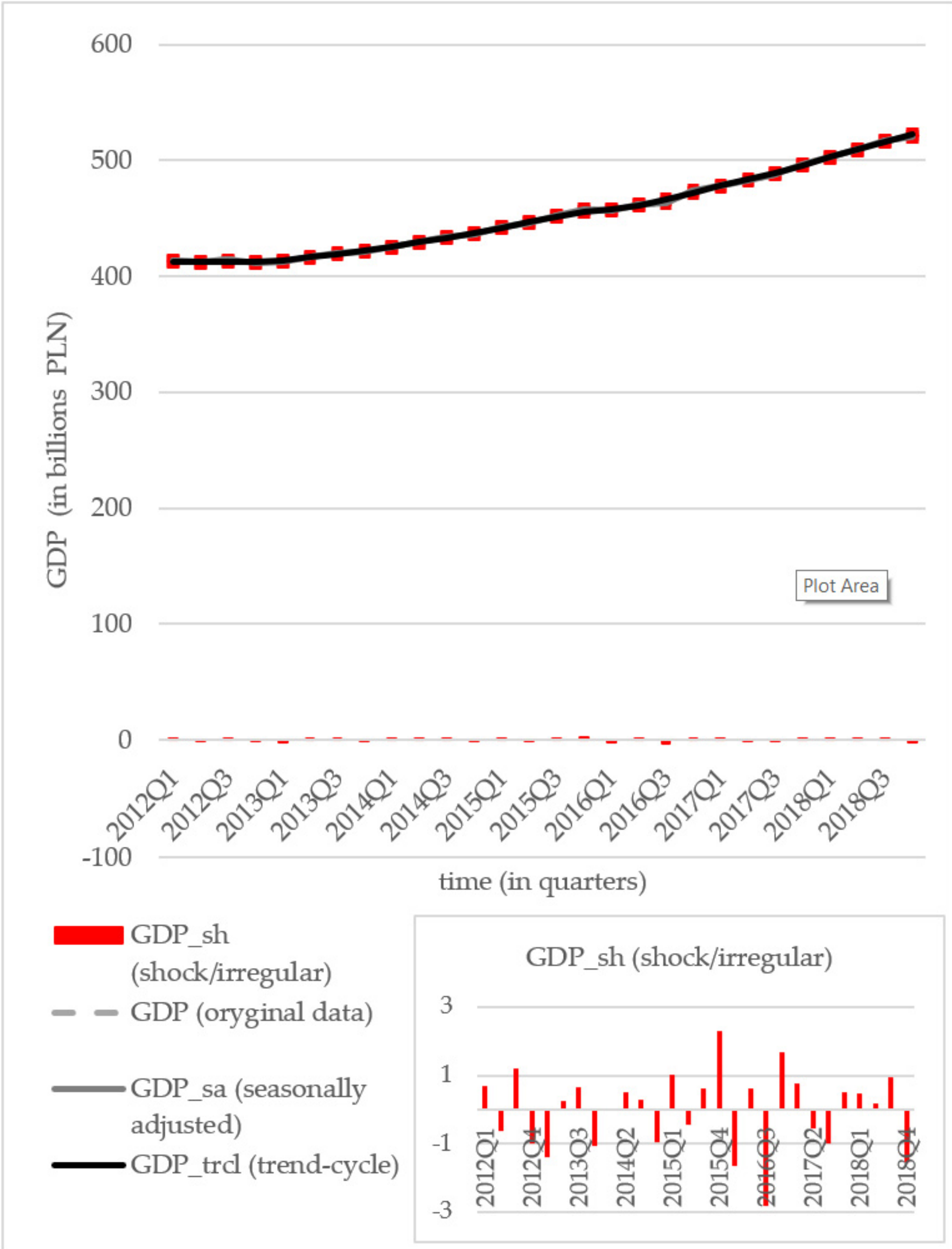

Figure 5. Decomposition of GDP into components by means of the TRAMO/SEATS method. GDP_sh is calculated as difference between GDP_sa and GDP_trcl. In the figure, this is shown three times (as difference, as absolute value and in zoom window as absolute value). The differences between all components are very small; therefore, in the graph the grey lines overlap with the black line. Source: own computation in Gretl software with TRAMO/SEATS packages based on data obtained from the OECD statistics database [92].

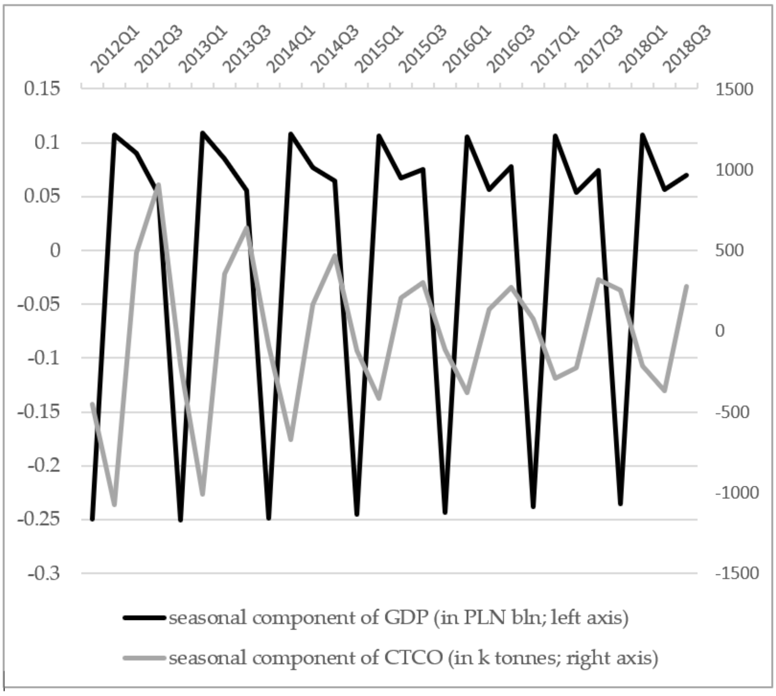

Figure 6. Seasonality of GDP and CTCO. The left axis is for seasonal component of GDP. The right axis is for seasonal component of CTCO. Source: own computation in Gretl software with TRAMO/SEATS packages based on data obtained from the Statistical Yearbooks of Maritime Economy [85–91] and the OECD statistics database [92].

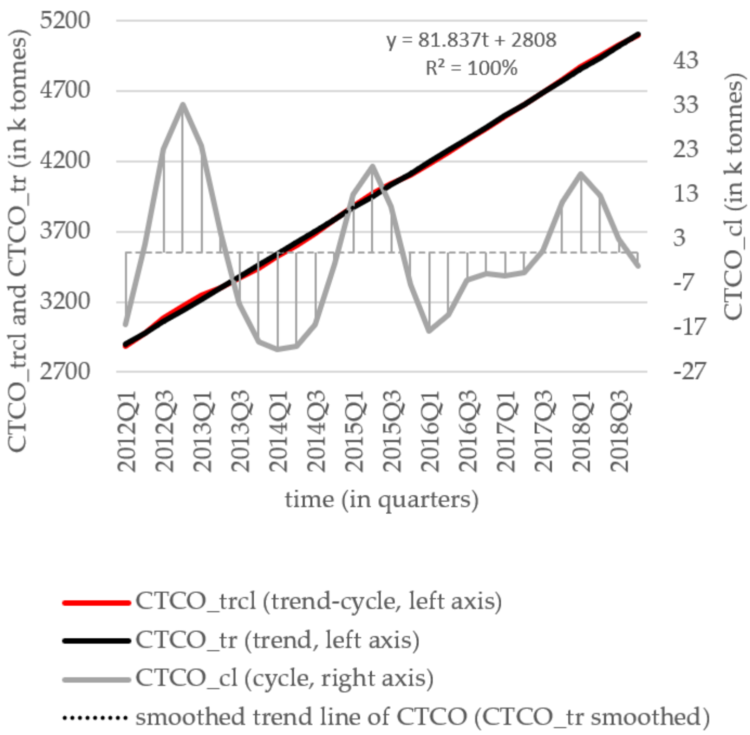

Figure 7. Decomposition of the trend-cycle component of CTCO by means of the Hodrick–Prescott filter (λ = 1600) (in k tonnes). The left axis is for CTCO_trcl and CTCO_tr. The right axis is for CTCO_cl. Source: own computation in Gretl software based on data obtained from the Statistical Yearbooks of Maritime Economy [85–91].

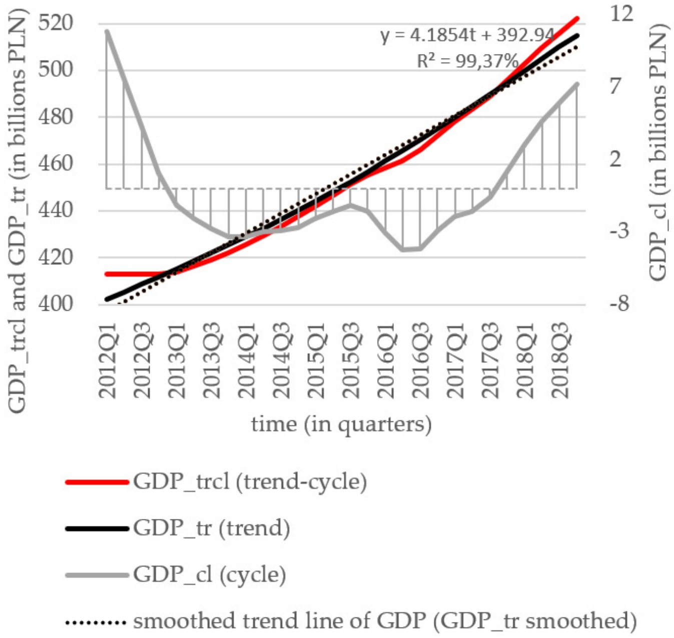

Figure 8. Decomposition of the trend-cycle component of GDP by means of the Hodrick–Prescott filter (λ = 1600) (in billions PLN). The left axis is for GDP_trcl and GDP_tr. The right axis is for GDP_cl. Source: own computation in Gretl software based on data obtained from the OECD statistics database [92].

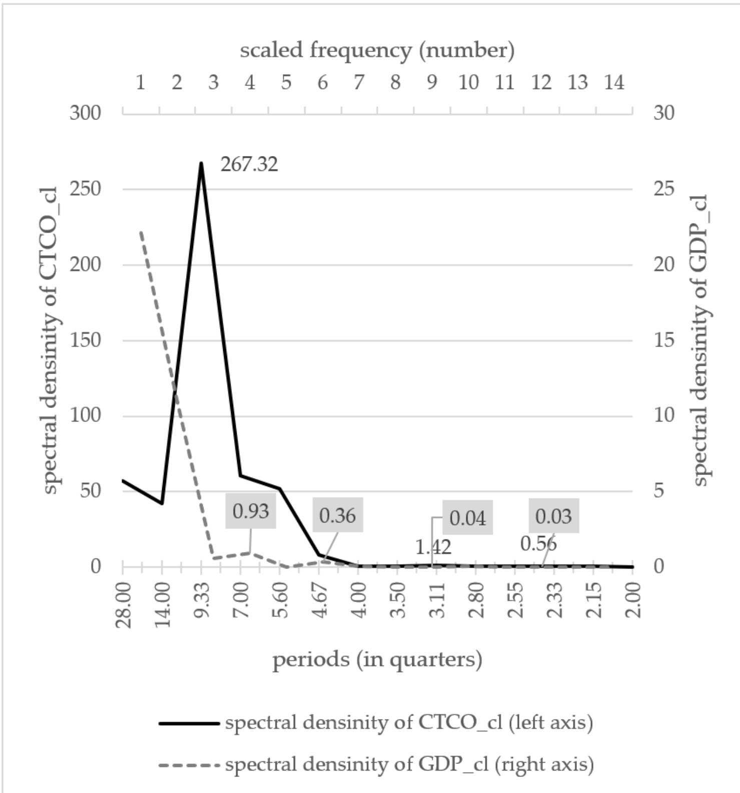

Figure 9. Periodogram for the CTCO and GDP cycles. Left axis for CTCO_cl; right axis for GDP_cl; values-labels in grey rectangles are for GDP, without grey rectangles—for CTCO. Source: own computation in Gretl software based on data obtained from the Statistical Yearbooks of Maritime Economy [85–91].

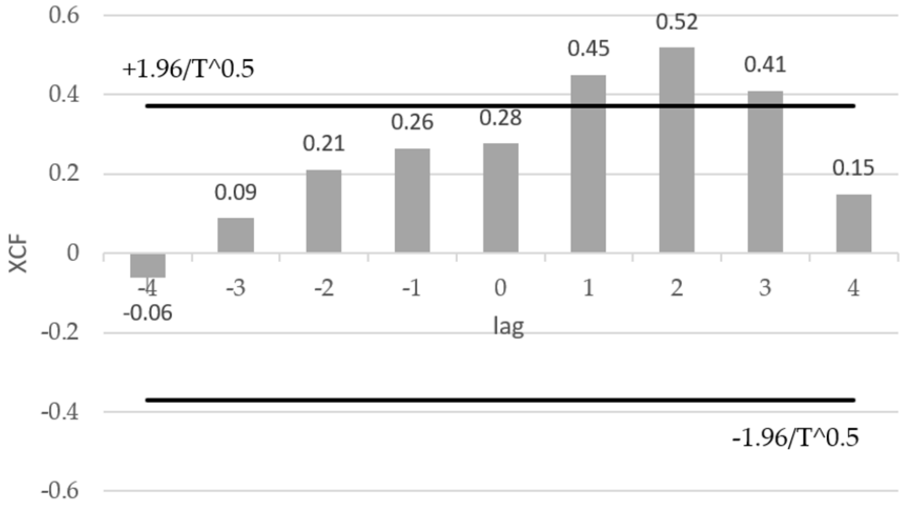

Figure 10. Cross-correlations of CTCO and lagged GDP_cl. XCF crossing the black lines are statistically significant at the level of *p*-value equal to 5%. Source: own computation in Gretl software based on the data presented in Table 4.

5. Discussion and Conclusions

This article achieved its purpose, which was to identify the relation between economic cycles of GDP and crude oil and oil products cargo volumes. The research hypothesis, which was formulated as follows: synchronisation of economic cycles of GDP and cargo traffic volumes is significant from the point of view of economic management, and it constitutes an early warning tool, was confirmed by the obtained results.

As it can be derived from the analysis of the cross-correlation function (XCF), the crude oil and oil products cargo volume cycles preceded the GDP cycles by 1–3 quarters, and the cross-correlation was significant and positive. Thus, it can be stated that crude oil and oil products cargo volumes may be a barometer of the economic situation and an early warning tool in economic management. Based on crude oil and oil products cargo volumes from the major Polish seaports, it is possible to recognise the directions of the economic cycle phases for the main measure of economic growth, i.e., GDP.

The results constitute a specific novelty for economic management, and undoubtedly the applied methodological approach may be used in many other fields of use in other countries that run maritime and port economies of particular importance. It seems that an ability to predict the next economic cycle by three quarters via the synchronisation of economic cycles, using the presented methodology, may constitute an interesting, pragmatic tool for decision-makers at a national and regional level.

This type of information might be used at the following areas:

1. Firstly, the obtained warning information may be used for development programming or planning via a shock analysis and analysing when they occur and phase out.
2. Secondly, they are significant from the point of view of trends and development rate evaluation.
3. Thirdly, they are valuable for the forecasting of development, as they take into account the cycle spans, multiplexity and complexity of various cycle occurrences (their leakage) and time lags (via specifying their lengths) as well as the depth of their occurrence. Thanks to the obtained results, it is known for how long the cycle phases may be extended.
4. Fourthly, the possibility to forecast the cycles and development gives the chance to effectively distribute and manage goods that stand in line with sustainable development and a fair system of global economy. It also leads to necessary changes in the business sector, which needs to improve sustainability conditions. As Vuong [96] stated, there is a need to move away from the downward spiral of eco-deficits to a new

eco-surplus culture and that value created for the environment should be rewarded with money.

Much effort was made through an investigation of the literature specialising in and proposing the synchronisation of economic cycles as an early warning tool in economic management in the context of the sustainable development concept. In the article, a holistic approach to the sustainable development of maritime ports through economic management was presented. The novelty was to introduce the early warning tool on the example of main maritime ports.

It is worth noting that analysed data did not cover the time of SARS-CoV-2, which had and still has a huge impact on global and national economies. The authors are preparing a study including this issue, as a very specific anomaly. COVID-19 had an impact on conditions in the crude oil and oil products market. On the demand side, containment measures and economic disruptions related to the COVID-19 pandemic have led to a slowdown in production and mobility worldwide [96–98]. The COVID-19 pandemic revealed the importance of seaports in the global supply chain. Since the port services were 'essential services', they could remain operational, whereas other national branches were shutdown. The reorganising of the working procedure, communication or at least minimising the number of people on shifts caused minor delays in cargo maritime ports. For the future, it is advisable to accelerate the digitalisation process [99]. The first quarter of the pandemic in 2020 in Polish ports (Gdańsk, Gdynia, Szczecin-Świnoujście) caused limited drops, mostly noticed in container turnover [100].

The article omits other important topics, such as oil price forecasts or air emission empirical research, which are crucial in the context of the development of early warning indicators and the decision-making process. However, it is impossible to refer to all of the important, interesting and future-oriented research. Currently, in-depth global research in this field is conducted by researchers [101–104]. In the context of future research, it is worth extending the analysis to the problem of forecasting oil prices and air emissions, paying attention to the interaction of such variables as oil prices, inflation, exchange rates and purchasing power parity. In this context, it is worth extending the tool apparatus with the Cobb–Douglas function and the Phillips curve for the Vector Error Correction Model. However, such a study requires a separate article.

Additionally, the study will be continued in order to estimate the cargo traffic output gap, and to estimate the size of the negative output gap, as well as the impact of the shock on the output gap. The authors plan to expand the research in the direction of Vector Error Correction Models with their structural form (AB model with shock system—Blanchard and Quah). It will be interesting from the point of view of decompose variance and structural shock. It is probably the one way to deeply capture the window of shock distinction.

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Informed Consent Statement: Not applicable.

Data Availability Statement: Data are contained within the article or supplementary material. To estimate the analysed results, the authors used raw data from the databases included in the references listed as [85–92].

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Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

AI	artificial intelligence
bln	billion
c_t	cycle, cyclical component in Hodrick–Prescott filter formula
CO_2	carbon dioxide
CTCO	cargo traffic of crude oil and oil products (k tonnes)
CTCO_cl	cycle for CTCO (filtered using the Hodrick–Prescott filter)
CTCO_sa	seasonally adjusted CTCO (estimated using TRAMO/SEATS)
CTCO_sh	irregular/shock component for CTCO (estimated using TRAMO/SEATS)
CTCO_tr	trend for CTCO (filtered using the Hodrick–Prescott filter)
CTCO_trcl	trend/cycle for CTCO (estimated using TRAMO/SEATS)
EU	European Union
EUR	euro currency
GDP	Gross Domestic Product (raw data in bln PLN, at constant prices)
GDP_cl	cycle for GDP (filtered using the Hodrick–Prescott filter)
GDP_sa	seasonally adjusted GDP (estimated using TRAMO/SEATS)
GDP_sh	irregular/shock component for GDP (estimated using TRAMO/SEATS)
GDP_tr	trend for GDP (filtered using the Hodrick–Prescott filter)
GDP_trcl	trend/cycle for GDP (estimated using TRAMO/SEATS)
IMO	International Maritime Organisation
IoT	Internet of Things
k	thousand
n	number of observations for correlation coefficients
OECD	Organisation for Economic Co-operation and Development
p-value	probability value, asymptotic significance
PLN	Polish currency, Polish zloty
R&D	Research and Development
SDG	Sustainable Development Goals
SEATS	Signal Extraction in ARIMA Time Series
SPI	Smart Port Index
T	number of observations in the formula of the Hodrick–Prescott filter
t	index of time, $t = 1, 2, \ldots, T$
TRAMO	Time series Regression with ARIMA noise, Missing observations, and Outliers
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
USD	currency of the USA, American dollar
WCED	United Nation's World Commission on Environment and Development
XCF	cross-correlation function
ϵ_t	shock, irregular component
λ	smoothing parameter in the formula of the Hodrick–Prescott filter
τ_t	smoothed series in the formula of the Hodrick–Prescott filter, trend
y_t	input series in formula of the Hodrick–Prescott filter: decompose into trend, cycle and shock

Appendix A

Table A1. Signal Extraction in 'ARIMA' Time Series for CTCO.

SIGNAL EXTRACTION IN 'ARIMA' TIME SERIES (BETA VERSION) (*)

BY

V. GOMEZ and A. MARAVALL,

with the programming assistance of G. CAPORELLO

Thanks are due to G. FIORENTINI and C. PLANAS for their research assistance

(Based on an original program developed by J. P. BURMAN at the Bank of England, version 1982)

(*) Copyright: V. GOMEZ, A. MARAVALL (1994,1996)

FIRST PART:
ARIMA ESTIMATION

SERIES TITLE: CTCO
PREADJUSTED WITH TRAMO: YES
METHOD: MAXIMUM LIKELIHOOD

NO OF OBSERVATIONS = 28

YEAR	1ST	2ND	3RD	4TH
2012	1866.600	1839.200	3880.600	4736.000
2013	3518.100	1790.600	3804.300	3626.200
2014	3504.800	2961.200	3275.800	4386.700
2015	3873.600	4169.600	4551.700	4099.000
2016	3574.600	3609.100	5070.800	4507.400
2017	4600.100	4343.600	3966.400	5408.300
2018	5506.200	4903.300	4457.000	5238.100

INPUT PARAMETERS

LAM = 1	IMEAN = 0	RSA = 0	MQ = 4
P = 0	BP = 0	Q = 1	BQ = 1
D = 1	BD = 1	NOADMISS = 1	RMOD = 0.500
M = 36	QMAX = 36	BIAS = 1	SMTR = 0
THTR = −0.400	MAXBIAS = 0.500	IQM = 16	OUT = 1
EPSPHI = 2.000	MAXIT = 20	XL = 0.990	SEK = 3.000

TRANSFORMATION: Z → Z

NONSEASONAL DIFFERENCING D = 1
SEASONAL DIFFERENCING BD = 1

DIFFERENCED SERIES

Table A1. *Cont.*

YEAR	1ST	2ND	3RD	4TH
2013		−1700.100	−27.700	−1033.500
2014	1096.500	1183.900	−1699.100	1289.000
2015	−391.700	839.600	67.500	−1563.600
2016	−11.300	−261.500	1079.600	−110.700
2017	617.100	−291.000	−1838.900	2005.300
2018	5.200	−346.400	−69.100	−660.800

MEAN OF DIFFERENCED SERIES −0.7920E+02

MEAN SET EQUAL TO ZERO

VARIANCE OF Z SERIES = 0.9436E+06

VARIANCE OF DIFFERENCED SERIES = 0.1048E+07

AUTOCORRELATIONS OF STATIONARY SERIES

−0.3547	−0.0206	−0.0072	−0.3347	0.4402
SE	0.2085	0.2333	0.2334	0.2334
0.1370	−0.2394	−0.0033	0.2356	−0.1264
SE	0.2925	0.2952	0.3036	0.3036
−0.3459	−0.0064	0.1586	−0.1106	0.1547
SE	0.3261	0.3417	0.3417	0.3449

PARTIAL AUTOCORRELATIONS

	−0.3547	−0.1675	−0.0884	−0.4429	0.1750	−0.1285
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085
	0.0781	−0.4014	0.0580	−0.0773	0.1178	0.1088
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085
	0.0062	−0.1237	0.1370	−0.0079	−0.0526	0.0278
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085

MODEL FITTED

NONSEASONAL P = 0 D = 1 Q = 1
SEASONAL BP = 0 BD = 1 BQ= 1
PERIODICITY MQ = 4

CONVERGED AFTER 11 ITERATIONS AND 29 FUNCTION VALUES F = 0.13265435E+08
0.990000E+00 0.462399E+00

PARAMETERS FIXED

Table A1. *Cont.*

1

PARAMETER ESTIMATES

MEAN = 0.00000

SE = *******

CORRELATION MATRIX

******
****** 1.000

ARIMA PARAMETERS

THETA = −0.9900
SE = *******

BTHETA= −0.4624
SE = 0.1678

RESIDUALS

YEAR	1ST	2ND	3RD	4TH
2012	−531.546	−55.657	302.937	626.179
2013	1072.403	−420.828	−278.764	−1158.608
2014	158.707	655.510	−986.401	−95.666
2015	117.359	1186.241	485.691	−675.451
2016	−581.937	−342.824	421.755	−227.828
2017	431.668	244.226	−1245.160	474.174
2018	778.530	339.667	−420.391	−287.726

TEST-STATISTICS ON RESIDUALS

MEAN = −0.4907E+00
ST.DEV. = 0.1171E+03
OF MEAN
T-VALUE = −0.0042

NORMALITY TEST = 0.5396 (CHI-SQUARED (2))
SKEWNESS = −0.1451 (SE = 0.4629)
KURTOSIS = 2.3850 (SE = 0.9258)

SUM OF SQUARES = 0.1076E+08

Table A1. *Cont.*

DURBIN–WATSON = 1.8390

STANDARD DEVI. = 0.7156E+03
OF RESID.
VARIANCE = 0.5121E+06
OF RESID.

AUTOCORRELATIONS OF RESIDUAL

	0.0636	−0.3430	−0.3254	−0.0905	0.2781	−0.1048
SE	0.1890	0.1897	0.2107	0.2280	0.2292	0.2410
	−0.0029	−0.2030	0.0156	0.2835	0.1447	0.1077
SE	0.2426	0.2426	0.2486	0.2486	0.2599	0.2628
	−0.3836	−0.1436	0.1633	0.1171	0.0161	−0.2165
SE	0.2644	0.2835	0.2861	0.2894	0.2911	0.2912

THE LJUNG–BOX Q VALUE IS 29.04
IF RESIDUALS ARE RANDOM, IT SHOULD BE DISTRIBUTED AS CHI-SQUARED (14)

INPUT PARAMETERS

LAM = 1	IMEAN = 0	RSA = 0	MQ = 4
P = 0	BP = 0	Q = 1	BQ = 1
D = 1	BD = 1	NOADMISS = 1	RMOD = 0.500
M = 23	QMAX = 36	BIAS = 1	SMTR = 0
THTR = −0.400	MAXBIAS = 0.500	IQM = 16	OUT = 1
EPSPHI = 2.000	MAXIT = 20	XL = 0.990	SEK = 3.000

TRANSFORMATION: Z → Z

NONSEASONAL DIFFERENCING D = 1
SEASONAL DIFFERENCING BD = 1

DIFFERENCED SERIES

YEAR	1ST	2ND	3RD	4TH
2013		−1700.100	−27.700	−1033.500
2014	1096.500	1183.900	−1699.100	1289.000
2015	−391.700	839.600	67.500	−1563.600
2016	−11.300	−261.500	1079.600	−110.700
2017	617.100	−291.000	−1838.900	2005.300
2018	5.200	−346.400	−69.100	−660.800

MEAN OF DIFFERENCED SERIES -0.7920×10^2

MEAN SET EQUAL TO ZERO

Table A1. *Cont.*

VARIANCE OF Z SERIES = 0.9436×10^6

VARIANCE OF DIFFERENCED SERIES = 0.1048×10^7

AUTOCORRELATIONS OF STATIONARY SERIES

	−0.3547	−0.0206	−0.0072	−0.3347	0.4402	−0.2271
SE	0.2085	0.2333	0.2334	0.2334	0.2534	0.2847
	0.1370	−0.2394	−0.0033	0.2356	−0.1264	0.3032
SE	0.2925	0.2952	0.3036	0.3036	0.3114	0.3136
	−0.3459	−0.0064	0.1586	−0.1106	0.1547	−0.1622
SE	0.3261	0.3417	0.3417	0.3449	0.3464	0.3494

PARTIAL AUTOCORRELATIONS

	−0.3547	−0.1675	−0.0884	−0.4429	0.1750	−0.1285
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085
	0.0781	−0.4014	0.0580	−0.0773	0.1178	0.1088
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085
	0.0062	−0.1237	0.1370	−0.0079	−0.0526	0.0278
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085

MODEL FITTED

NONSEASONAL P = 0 D = 1 Q = 1
SEASONAL BP = 0 BD = 1 BQ = 1
PERIODICITY MQ = 4

CONVERGED AFTER 11 ITERATIONS AND 29 FUNCTION VALUES F = 0.13265435E+08
0.990000E+00 0.462399E+00

PARAMETERS FIXED
1

PARAMETER ESTIMATES

MEAN = 0.00000

Table A1. *Cont.*

SE = *******

CORRELATION MATRIX

******
****** 1.000

ARIMA PARAMETERS

THETA = −0.9900
SE = *******

BTHETA = −0.4624
SE = 0.1678

RESIDUALS

YEAR	1ST	2ND	3RD	4TH
2012	−531.546	−55.657	302.937	626.179
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2015	117.359	1186.241	485.691	−675.451
2016	−581.937	−342.824	421.755	−227.828
2017	431.668	244.226	−1245.160	474.174
2018	778.530	339.667	−420.391	−287.726

TEST-STATISTICS ON RESIDUALS

MEAN = −0.4907E+00
ST.DEV. = 0.1171E+03
OF MEAN
T-VALUE = −0.0042

NORMALITY TEST = 0.5396 (CHI-SQUARED (2))
SKEWNESS = −0.1451 (SE = 0.4629)
KURTOSIS = 2.3850 (SE = 0.9258)

SUM OF SQUARES = 0.1076E+08

DURBIN–WATSON = 1.8390

STANDARD DEVI. = 0.7156E+03
OF RESID.
VARIANCE = 0.5121E+06
OF RESID.

Table A1. *Cont.*

AUTOCORRELATIONS OF RESIDUAL

	0.0636	−0.3430	−0.3254	−0.0905	0.2781	−0.1048
SE	0.1890	0.1897	0.2107	0.2280	0.2292	0.2410
	−0.0029	−0.2030	0.0156	0.2835	0.1447	0.1077
SE	0.2426	0.2426	0.2486	0.2486	0.2599	0.2628
	−0.3836	−0.1436	0.1633	0.1171	0.0161	−0.2165
SE	0.2644	0.2835	0.2861	0.2894	0.2911	0.2912

THE LJUNG–BOX Q VALUE IS 29.04
IF RESIDUALS ARE RANDOM, IT SHOULD BE DISTRIBUTED AS CHI-SQUARED (14)

APPROXIMATE TEST OF RUNS ON RESIDUALS

NUM.DATA = 28
NUM. (+) = 14
NUM. (−) = 14
T-VALUE = −0.770

AUTOCORRELATIONS OF SQUARED RESIDUAL

	−0.2569	−0.1377	0.2115	−0.2014
SE	0.1890	0.2011	0.2044	0.2121
	−0.0975	−0.1342	0.3623	−0.1160
SE	0.2384	0.2399	0.2425	0.2611
	−0.0688	−0.1339	0.2076	−0.0929
SE	0.2636	0.2642	0.2666	0.2723

THE LJUNG–BOX Q VALUE IS 21.34
IF RESIDUALS ARE RANDOM, IT SHOULD BE DISTRIBUTED AS CHI-SQUARED (14)

BACKWARD RESIDUALS

YEAR	1ST	2ND	3RD	4TH
2012	−1161.151	−144.921	635.738	1354.892
2013	382.797	−1104.070	515.712	−195.358
2014	66.066	−570.972	−761.273	497.780
2015	216.779	673.934	429.115	−242.701
2016	−888.413	−484.704	1324.585	−366.122
2017	−412.914	−160.287	−255.526	437.112
2018	359.691	161.981	−189.797	−131.714

SECOND PART:
DERIVATION OF THE MODELS FOR THE COMPONENTS

SERIES TITLE: CTCO

MODEL PARAMETERS
(0,1,1) (0,1,1)

Table A1. *Cont.*

PARAMETER VALUES PASSED FROM ARIMA ESTIMATION (TRUE SIGNS)

THETA PARAMETERS
1.00 −0.99

BTHETA PARAMETERS

1.00	0.00	0.00	0.00	−0.46

PHI PARAMETERS
1

BPHI PARAMETERS
1

NUMERATOR OF THE MODEL

1.0000	−0.9900	0.0000	0.0000	−0.4624	0.4578

STATIONARY AUTOREGRESSIVE TREND-CYCLE
1

NON-STATIONARY AUTOREGRESSIVE TREND-CYCLE

1.0000	−2.0000	1.0000

AUTOREGRESSIVE TREND-CYCLE

1.0000	−2.0000	1.0000

STATIONARY AUTOREGRESSIVE TRANSITORY COMP.
1

NON-STATIONARY AUTOREGRESSIVE TRANSITORY COMP.
1

AUTOREGRESSIVE TRANSITORY COMP.

1

STATIONARY AUTOREGRESSIVE SEASONAL COMPONENT
1

NON-STATIONARY AUTOREGRESSIVE SEASONAL COMPONENT

1.0000	1.0000	1.0000	1.0000

AUTOREGRESSIVE SEASONAL COMPONENT

1.0000	1.0000	1.0000	1.0000

STATIONARY AUTOREGRESSIVE SEASONALLY ADJUSTED COMPONENT
1

NON-STATIONARY AUTOREGRESSIVE SEASONALLY ADJUSTED COMPONENT

1.0000	−2.0000	1.0000

AUTOREGRESSIVE SEASONALLY ADJUSTED COMPONENT

1.0000	−2.0000	1.0000

Table A1. *Cont.*

TOTAL DENOMINATOR

1.0000	−1.0000	0.0000	0.0000	−1.0000	1.0000

MA ROOTS OF TREND−CYCLE

REAL PART	IMAGINARY PART	MODULUS	ARGUMENT (DEG.)	PERIOD
0.990	0.000	0.990	0.000	–
−1.000	0.000	1.000	180.000	2.0

TOTAL SQUARED ERROR= 0.1194682E−35

MA ROOTS OF SEAS.

REAL PART	IMAGINARY PART	MODULUS	ARGUMENT (DEG.)	PERIOD
−0.410	0.420	0.587	134.295	2.681
1.000	0.000	1.000	0.000	–

TOTAL SQUARED ERROR = 0.3123552E−29

MA ROOTS OF SEASONALLY ADJUSTED SERIES

REAL PART	IMAGINARY PART	MODULUS	ARGUMENT (DEG.)	PERIOD
0.825	0.000	0.825	0.000	-
0.990	0.000	0.990	0.000	-

TOTAL SQUARED ERROR = 0.3729890E−30

MODELS FOR THE COMPONENTS

TREND-CYCLE NUMERATOR

1.0000	0.0100	−0.9900

TREND-CYCLE DENOMINATOR

1.0000	−2.0000	1.0000

INNOV. VAR. (*) 0.00453

Table A1. *Cont.*

SEAS. NUMERATOR

1.0000	−0.1805	−0.4752	−0.3442

SEAS. DENOMINATOR

1.0000	1.0000	1.0000	1.0000

INNOV. VAR. (*) 0.06494

IRREGULAR
VAR. 0.48461

SEASONALLY ADJUSTED NUMERATOR

1.0000	−1.8147	0.8165

SEASONALLY ADJUSTED DENOMINATOR

1.0000	−2.0000	1.0000

INNOV. VAR. (*) 0.58804

(*) IN UNITS OF VAR (A)

MOVING AVERAGE REPRESENTATION OF ESTIMATORS (NONSTATIONARY)

The last column (the sum of the Psi-Weights) should be zero for negative lags, 1 for lag = 0, and equal to the Box–Jenkins Psi-Weights for positive lags.

PSIEP (LAG), for example, represents the effect of the overall innovation a (t-lag) on the estimator of the trend for period t. Similarly for the other components.

LAG	PSIEP	PSIES	PSIEC	PSIEA	PSIUE	PSIEP + PSIES + PSIUE
−8	0.0310	0.0914	0.0000	−0.0914	−0.1225	0.0000
−7	0.0386	−0.0366	0.0000	0.0366	−0.0020	0.0000
−6	0.0473	−0.0453	0.0000	0.0453	−0.0020	0.0000
−5	0.0561	−0.0541	0.0000	0.0541	−0.0020	0.0000
−4	0.0675	0.1978	0.0000	−0.1978	−0.2652	0.0000
−3	0.0838	−0.0791	0.0000	0.0791	−0.0047	0.0000
−2	0.1027	−0.0979	0.0000	0.0979	−0.0048	0.0000
−1	0.1218	−0.1170	0.0000	0.1170	−0.0048	0.0000
0	0.1366	0.3788	0.0000	0.6212	0.4846	1.0000
1	0.1424	−0.1324	0.0000	0.1424	0.0000	0.0100
2	0.1437	−0.1337	0.0000	0.1437	0.0000	0.0100
3	0.1451	−0.1351	0.0000	0.1451	0.0000	0.0100
4	0.1464	0.4012	0.0000	0.1464	0.0000	0.5476
5	0.1478	−0.1324	0.0000	0.1478	0.0000	0.0154
6	0.1491	−0.1337	0.0000	0.1491	0.0000	0.0154
7	0.1504	−0.1351	0.0000	0.1504	0.0000	0.0154
8	0.1518	0.4012	0.0000	0.1518	0.0000	0.5530

Table A1. *Cont.*

WIENER–KOLMOGOROV FILTERS (ONE SIDE)					
TREND-CYCLE COMPONENT					
0.0859	0.0798	0.0674	0.0550	0.0443	0.0369
0.0311	0.0254	0.0205	0.0170	0.0144	0.0117
0.0095	0.0079	0.0067	0.0054	0.0044	0.0036
0.0031	0.0025	0.0020	0.0017	0.0014	0.0012
0.0009	0.0008	0.0006	0.0005	0.0004	0.0004
0.0003	0.0002	0.0002	0.0002	0.0001	0.0001
0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SA SERIES COMPONENT					
0.7552	0.0796	0.0672	0.0548	−0.1358	0.0368
0.0311	0.0254	−0.0628	0.0170	0.0144	0.0117
−0.0290	0.0079	0.0066	0.0054	−0.0134	0.0036
0.0031	0.0025	−0.0062	0.0017	0.0014	0.0012
−0.0029	0.0008	0.0007	0.0005	−0.0013	0.0004
0.0003	0.0002	−0.0006	0.0002	0.0001	0.0001
−0.0003	0.0001	0.0001	0.0001	−0.0001	0.0000
0.0000	0.0000	−0.0001	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SEASONAL COMPONENT					
0.2448	−0.0796	−0.0672	−0.0548	0.1358	−0.0368
−0.0311	−0.0254	0.0628	−0.0170	−0.0144	−0.0117
0.0290	−0.0079	−0.0066	−0.0054	0.0134	−0.0036
−0.0031	−0.0025	0.0062	−0.0017	−0.0014	−0.0012
0.0029	−0.0008	−0.0007	−0.0005	0.0013	−0.0004
−0.0003	−0.0002	0.0006	−0.0002	−0.0001	−0.0001
0.0003	−0.0001	−0.0001	−0.0001	0.0001	0.0000
0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
IRREGULAR COMPONENT					
0.6692	−0.0002	−0.0002	−0.0001	−0.1801	−0.0001
−0.0001	−0.0001	−0.0833	0.0000	0.0000	0.0000
−0.0385	0.0000	0.0000	0.0000	−0.0178	0.0000
0.0000	0.0000	−0.0082	0.0000	0.0000	0.0000
−0.0038	0.0000	0.0000	0.0000	−0.0017	0.0000
0.0000	0.0000	−0.0008	0.0000	0.0000	0.0000
−0.0004	0.0000	0.0000	0.0000	−0.0002	0.0000
0.0000	0.0000	−0.0001	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
AUTOCORRELATION FUNCTION OF COMPONENTS (STATIONARY TRANSFORMATION)					
TREND-CYCLE			ADJUSTED		

Table A1. *Cont.*

LAG	COMPONENT	ESTIMATOR	ESTIMATE	COMPONENT	ESTIMATOR	ESTIMATE
1	0.000	0.667	0.508	−0.665	−0.662	−0.598
2	−0.500	0.122	−0.258	0.165	0.119	0.112
3	0.000	−0.178	−0.496	0.000	0.178	0.079
4	0.000	−0.268	−0.235	0.000	−0.269	−0.343
VAR. (*)	0.009	0.000	0.000	2.917	1.959	1.297

(*) IN UNITS OF VAR (A)

AUTOCORRELATION FUNCTION OF COMPONENTS (STATIONARY TRANSFORMATION)

	IRREGULAR			SEASONAL		
LAG	COMPONENT	ESTIMATOR	ESTIMATE	COMPONENT	ESTIMATOR	ESTIMATE
1	0.000	0.000	0.077	0.050	−0.156	0.058
2	0.000	0.000	−0.224	−0.300	−0.522	−0.781
3	0.000	0.000	−0.365	−0.250	−0.230	−0.255
4	0.000	−0.269	−0.285	0.000	0.614	0.531
VAR. (*)	0.485	0.324	0.263	0.089	0.027	0.029

(*) IN UNITS OF VAR (A)

For all components it should happen that:
-Var (Component) > Var (Estimator)
-Var (Estimator) close to Var (Estimate)

CROSSCORRELATION BETWEEN STATIONARY TRANSFORMATION OF ESTIMATORS

	ESTIMATOR	ESTIMATE
TREND/SEASONAL	−0.208	−0.420
SEASONAL/IRREGULAR	0.223	0.122
TREND-CYCLE/IRREGULAR	−0.408	−0.359

PSEUDO-INNOVATIONS IN THE COMPONENTS

PSEUDO INNOVATIONS IN TREND-CYCLE

Table A1. *Cont.*

YEAR	1ST	2ND	3RD	4TH
2012	1.29	4.44	4.71	−0.40
2013	−6.70	−4.82	−0.43	−0.76
2014	1.04	−2.49	−5.30	1.83
2015	9.17	9.08	0.44	−6.32
2016	−8.52	−4.30	0.85	−0.09
2017	3.42	6.81	10.67	10.76
2018	0.06	−8.95	−11.17	−5.26

PSEUDO INNOVATIONS IN SEASONAL

YEAR	1ST	2ND	3RD	4TH
2012	6.43	11.78	−9.71	−50.48
2013	−20.87	98.15	47.08	−73.89
2014	−130.08	146.66	38.63	−55.92
2015	0.43	−2.75	−48.00	−42.55
2016	106.03	83.07	−99.34	−62.87
2017	16.90	172.35	−87.56	−154.34
2018	31.35	74.57	80.36	−75.40

PSEUDO INNOVATIONS IN SEASONALLY ADJUSTED SERIES

YEAR	1ST	2ND	3RD	4TH
2012	−138.15	−169.71	241.55	412.81
2013	253.23	−607.35	27.64	−2.49
2014	−207.53	610.11	−366.37	−517.66
2015	−226.93	445.16	687.41	45.90
2016	45.79	−690.94	41.11	78.88
2017	−456.70	170.87	−429.09	662.73
2018	727.65	239.23	−204.89	−682.81

THIRD PART:
ERROR ANALYSIS

	FINAL ESTIMATION ERROR		REVISION IN CONCURRENT ESTIMATOR	
ACF (LAG)	TREND-CYCLE	ADJUSTED	TREND-CYCLE	AD-JUSTED
1	0.912	−0.320	0.827	−0.104
2	0.752	−0.277	0.677	−0.216
3	0.620	−0.224	0.555	−0.313
4	0.511	0.553	0.460	0.462
VAR. (*)	0.043	0.120	0.047	0.087

TOTAL ESTIMATION ERROR (CONCURRENT ESTIMATOR)

ACF (LAG)	TREND-CYCLE	ADJUSTED
1	0.867	−0.229
2	0.713	−0.251
3	0.586	−0.262
4	0.484	0.515
VAR. (*)	0.089	0.207

Table A1. *Cont.*

(*) IN UNITS OF VAR (A)

VARIANCE OF THE REVISION ERROR (*)

ADDITIONAL PERIODS	TREND-CYCLE	ADJUSTED
0	0.4687E−01	0.8729E−01
4	0.9909E−02	0.1866E−01
8	0.2071E−02	0.3990E−02
12	0.4239E−03	0.8532E−03
16	0.8437E−04	0.1824E−03
20	0.1723E−04	0.3900E−04

PERCENTAGE REDUCTION IN THE STANDARD ERROR OF THE REVISION AFTER ADDITIONAL YEARS
(COMPARISON WITH CONCURRENT ESTIMATORS)

AFTER 1 YEAR	54.02	53.76
AFTER 2 YEAR	78.98	78.62
AFTER 3 YEAR	90.49	90.11
AFTER 4 YEAR	95.76	95.43
AFTER 5 YEAR	98.08	97.89

VARIANCE OF THE REVISION ERROR FOR THE SEASONAL COMPONENT (ONE YEAR AHEAD ADJUSTMENT)

PERIODS AHEAD	VARIANCE (*)
0	0.8729E−01
1	0.2308
2	0.2483
3	0.2662
4	0.2845

AVERAGE PERCENTAGE REDUCTION IN RMSE FROM CONCURRENT ADJUSTMENT 35.24

(*) IN UNITS OF VAR (A)

DECOMPOSITION OF THE SERIES: RECENT ESTIMATES

Table A1. *Cont.*

PERIOD	SERIES	TREND-CYCLE			ADJUSTED		
		ESTIMATE	STANDARD ERROR	TOTAL OF REVISION	ESTIMATE	STANDARD ERROR	TOTAL OF REVISION
−8	4507	4438	151.3	32.57	4238	251.6	45.21
−7	4600	4520	152.9	39.41	4526	260.0	79.54
−6	4344	4604	155.4	48.11	4634	261.3	83.73
−5	3966	4691	159.0	58.83	4193	263.3	89.78
−4	5408	4785	164.0	71.24	5088	266.1	97.77
−3	5506	4875	171.0	86.06	5254	301.4	172.0
−2	4903	4953	181.2	104.9	5121	306.7	181.1
−1	4457	5026	195.5	128.1	4824	314.6	194.2
0	5238	5103	214.1	154.9	4963	325.5	211.4

STANDARD ERROR OF 147.7 247.5
FINAL ESTIMATOR

PERIOD	SEASONAL		
	ESTIMATE	STANDARD ERROR	TOTAL OF REVISION
−8	269.2	251.6	45.21
−7	73.99	260.0	79.54
−6	−290.0	261.3	83.73
−5	−226.1	263.3	89.78
−4	320.3	266.1	97.77
−3	252.5	301.4	172.0
−2	−217.4	306.7	181.1
−1	−366.6	314.6	194.2
0	274.9	325.5	211.4

STANDARD ERROR OF 247.5
FINAL ESTIMATOR

DECOMPOSITION OF THE SERIES: FORECAST

PERIOD	SERIES		TREND-CYCLE			ADJUSTED		
	FORECAST	S.E.	FORECAST	STANDARD ERROR	TOTAL OF REVISION	FORECAST	STANDARD ERROR	TOTAL OF REVISION
1	5478	715.6	5184	235.3	183.2	5184	551.0	492.3
2	5074	715.7	5266	256.4	209.6	5266	560.3	502.7
3	4978	715.7	5349	276.3	233.5	5349	569.7	513.1
4	5700	715.8	5431	295.2	255.5	5431	579.1	523.5
5	5808	816.0	5514	313.2	276.2	5514	588.5	533.9
6	5404	816.1	5596	330.6	295.7	5596	597.9	544.3
7	5308	816.2	5679	347.4	314.4	5679	607.3	554.6
8	6029	816.2	5761	363.7	332.3	5761	616.8	565.0

Table A1. *Cont.*

PERIOD	SEASONAL		
	FORECAST	TOTAL OF REVISION	STANDARD ERROR
1	294.1	423.6	343.8
2	−191.9	434.1	356.6
3	−370.8	444.5	369.2
4	268.5	454.9	381.7
5	294.1	537.9	477.6
6	−191.9	546.2	486.9
7	−370.8	554.5	496.2
8	268.5	562.9	505.6

CONFIDENCE INTERVAL AROUND A SEASONAL COMPONENT OF 0

	FINAL ESTIMATOR		CONCURRENT ESTIMATOR	
95% CONFIDENCE INTERVAL	−485.1	485.1	−638.0	638.0
70% CONFIDENCE INTERVAL	−256.7	256.7	−337.6	337.6

SAMPLE MEANS

	COMPLETE PERIOD	LAST THREE YEARS
SERIES	3967	4599
TREND-CYCLE	3995	4649
ADJUSTED	3995	4621
SEASONAL	−27.94	−22.18

STANDARD ERROR OF ALTERNATIVE MEASURES OF GROWTH
(NONANNUALISED GROWTH)

1. PERIOD TO PERIOD GROWTH OF THE SERIES

	TREND-CYCLE	SEASONALLY ADJ. SERIES
CONCURRENT ESTIMATOR	67.534	503.460
1—PERIOD REVISION	66.137	503.275
2—PERIOD REVISION	64.737	503.094
3—PERIOD REVISION	63.674	462.453
4—PERIOD REVISION	63.155	425.890
5—PERIOD REVISION	62.838	425.843
6—PERIOD REVISION	62.526	425.798
7—PERIOD REVISION	62.292	415.829
8—PERIOD REVISION	62.179	407.393

Table A1. *Cont.*

FINAL ESTIMATOR		61.911		402.215
3. ACCUMULATED GROWTH OVER THE LAST QUARTER OF PREVIOUS YEAR				
	CONCURRENT ESTIMATOR		FINAL ESTIMATOR	
	TREND-CYCLE	SEASONALLY ADJ. SERIES	TREND-CYCLE	SEASONALLY ADJ. SERIES
QUARTER 1	270.135	2013.839	247.645	1608.859
QUARTER 2	230.983	1006.489	208.088	791.175
QUARTER 3	194.733	669.655	171.699	516.343
QUARTER 4	168.324	260.152	146.033	234.006

(CENTERED) ESTIMATOR OF THE PRESENT ANNUAL GROWTH

STANDARD ERROR	TREND-CYCLE	SEAS. ADJ. SERIES	ORIGINAL SERIES
CONCURRENT ESTIMATOR	182.745	643.638	715.714
FINAL ESTIMATOR	146.033	234.006	0.000

FOURTH PART:
ESTIMATES OF THE COMPONENTS (LEVELS)

ORIGINAL SERIES

YEAR	1ST	2ND	3RD	4TH
2012	1866.600	1839.200	3880.600	4736.000
2013	3518.100	1790.600	3804.300	3626.200
2014	3504.800	2961.200	3275.800	4386.700
2015	3873.600	4169.600	4551.700	4099.000
2016	3574.600	3609.100	5070.800	4507.400
2017	4600.100	4343.600	3966.400	5408.300
2018	5506.200	4903.300	4457.000	5238.100

SEASONAL COMPONENT

YEAR	1ST	2ND	3RD	4TH
2012	−450.816	−1075.008	485.251	904.432
2013	−209.543	−1007.740	354.343	636.675
2014	−88.342	−669.293	167.830	468.889
2015	−117.503	−418.540	204.620	298.699
2016	−113.237	−379.628	135.842	269.207
2017	73.989	−289.983	−226.118	320.264
2018	252.491	−217.390	−366.567	274.923

STANDARD ERROR OF SEASONAL

YEAR	1ST	2ND	3RD	4TH
2012	325.516	314.570	306.666	301.403
2013	266.112	263.283	261.281	259.968
2014	251.597	250.960	250.512	250.220
2015	248.384	248.149	248.246	248.384

Table A1. *Cont.*

2016	250.220	250.512	250.960	251.597
2017	259.968	261.281	263.283	266.112
2018	301.403	306.666	314.570	325.516
		TREND-CYCLE		
YEAR	1ST	2ND	3RD	4TH
2012	2880.125	2978.811	3080.988	3171.839
2013	3243.089	3303.945	3368.921	3441.254
2014	3520.524	3602.370	3688.396	3783.659
2015	3880.790	3968.908	4041.723	4105.986
2016	4177.612	4263.672	4353.976	4437.923
2017	4520.136	4603.811	4691.496	4785.336
2018	4874.685	4952.665	5025.900	5102.613
		STANDARD ERROR OF TREND-CYCLE		
YEAR	1ST	2ND	3RD	4TH
2012	214.081	195.529	181.186	170.973
2013	164.011	159.016	155.370	152.899
2014	151.280	150.151	149.346	148.811
2015	148.466	148.060	148.228	148.466
2016	148.811	149.346	150.151	151.280
2017	152.899	155.370	159.016	164.011
2018	170.973	181.186	195.529	214.081
		SEASONALLY ADJUSTED SERIES		
YEAR	1ST	2ND	3RD	4TH
2012	2317.416	2914.208	3395.349	3831.568
2013	3727.643	2798.340	3449.957	2989.525
2014	3593.142	3630.493	3107.970	3917.811
2015	3991.103	4588.140	4347.080	3800.301
2016	3687.837	3988.728	4934.958	4238.193
2017	4526.111	4633.583	4192.518	5088.036
2018	5253.709	5120.690	4823.567	4963.177
		STANDARD ERROR OF SEASONALLY ADJUSTED SERIES		
YEAR	1ST	2ND	3RD	4TH
2012	325.516	314.570	306.666	301.403
2013	266.112	263.283	261.281	259.968
2014	251.597	250.960	250.512	250.220
2015	248.384	248.149	248.246	248.384
2016	250.220	250.512	250.960	251.597
2017	259.968	261.281	263.283	266.112
2018	301.403	306.666	314.570	325.516
		IRREGULAR COMPONENT		
YEAR	1ST	2ND	3RD	4TH
2012	−562.710	−64.604	314.361	659.729
2013	484.554	−505.605	81.036	−451.729
2014	72.618	28.123	−580.425	134.152
2015	110.313	619.232	305.357	−305.686
2016	−489.775	−274.944	580.982	−199.730
2017	5.975	29.772	−498.978	302.699

Table A1. *Cont.*

2018	379.024	168.025	−202.333	−139.436

* * PROCESSING COMPLETED * *

Source: own computation in Gretl software with TRAMO/SEATS packages based on Table 4.

Table A2. Signal Extraction in 'ARIMA' Time Series for GDP.

SIGNAL EXTRACTION IN 'ARIMA' TIME SERIES (BETA VERSION) (*)

BY

V. GOMEZ and A. MARAVALL,

with the programming assistance of G. CAPORELLO

Thanks are due to G. FIORENTINI and C. PLANAS for their research assistance

(Based on an original program developed by J. P. BURMAN at the Bank of England, version 1982)

(*) Copyright: V. GOMEZ, A. MARAVALL (1994,1996)

FIRST PART:
ARIMA ESTIMATION

SERIES TITLE: GDP
PREADJUSTED WITH TRAMO: YES
METHOD: MAXIMUM LIKELIHOOD

NO OF OBSERVATIONS = 28

YEAR	1ST	2ND	3RD	4TH
2012	413.498	412.485	414.295	412.108
2013	412.408	416.854	420.011	421.123
2014	425.472	430.316	433.917	436.726
2015	442.944	446.427	452.085	457.642
2016	456.344	462.331	463.510	474.004
2017	478.603	482.829	488.264	496.584
2018	503.152	509.849	516.884	520.822

INPUT PARAMETERS

LAM = 1	IMEAN = 1	RSA = 0	MQ = 4
P = 0	BP = 0	Q = 1	BQ = 1
D = 1	BD = 1	NOADMISS = 1	RMOD = 0.500
M = 36	QMAX = 36	BIAS = 1	SMTR = 0
THTR = −0.400	MAXBIAS = 0.500	IQM = 16	OUT = 1
EPSPHI = 2.000	MAXIT = 20	XL = 0.990	SEK = 3.000

TRANSFORMATION: $Z \rightarrow Z$

NONSEASONAL DIFFERENCING D = 1
SEASONAL DIFFERENCING BD = 1

Table A2. *Cont.*

DIFFERENCED SERIES

YEAR	1ST	2ND	3RD	4TH
2013	5.459	1.347	3.299	
2014	4.049	0.398	0.444	1.697
2015	1.869	−1.361	2.057	2.748
2016	−7.516	2.504	−4.479	4.937
2017	5.897	−1.761	4.256	−2.174
2018	1.969	2.471	1.600	−4.382

SERIES HAS BEEN MEAN CORRECTED

DIFFERENCED AND CENTERED SERIES

YEAR	1ST	2ND	3RD	4TH
2013	4.358	0.246	2.198	
2014	2.948	−0.703	−0.657	0.596
2015	0.768	−2.462	0.956	1.647
2016	−8.617	1.403	−5.580	3.836
2017	4.796	−2.862	3.155	−3.275
2018	0.868	1.370	0.499	−5.483

MEAN OF DIFFERENCED SERIES 0.1101E+01

VARIANCE OF Z SERIES = 0.1188E+04

VARIANCE OF DIFFERENCED SERIES = 0.1091E+02

AUTOCORRELATIONS OF STATIONARY SERIES

	−0.2790	0.1059	0.0428	−0.2485	0.1982	−0.0861
SE	0.2085	0.2242	0.2263	0.2267	0.2382	0.2453
	0.0100	−0.1925	0.0074	−0.0569	0.0277	0.0559
SE	0.2466	0.2466	0.2531	0.2531	0.2536	0.2538
	−0.1045	0.1487	0.0480	−0.0832	0.0882	−0.0228
SE	0.2543	0.2562	0.2599	0.2603	0.2614	0.2627

PARTIAL AUTOCORRELATIONS

	−0.2790	0.0304	0.0868	−0.2388	0.0738	0.0231
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085
	−0.0148	−0.2932	−0.0428	−0.0584	0.0085	−0.0450
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085
	−0.0546	0.0925	0.1576	−0.1486	−0.0489	0.0870
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085

Table A2. *Cont.*

MODEL FITTED

NONSEASONAL P = 0 D = 1 Q = 1
SEASONAL BP = 0 BD = 1 BQ = 1
PERIODICITY MQ = 4

20 ITERATIONS COMPLETED
58 FUNCTION VALUES F = 0.18578351E+03
0.276250E+00 0.940575E+00

PARAMETERS FIXED
0

PARAMETER ESTIMATES

MEAN = 1.10122

SE = 0.226077

CORRELATION MATRIX

1.000	
0.141	1.000

ARIMA PARAMETERS

THETA = −0.2762
SE = 0.1965

BTHETA= −0.9406
SE = 0.1811

RESIDUALS

YEAR	1ST	2ND	3RD	4TH
2012	0.482	−1.680	0.642	−2.966
2013	−1.520	2.233	1.902	−0.233
2014	2.225	2.406	1.217	0.218
2015	2.981	0.046	1.488	1.947
2016	−5.332	−0.801	−4.414	4.061
2017	0.397	−2.121	−1.375	1.312
2018	0.548	−0.577	−0.403	−4.003

TEST-STATISTICS ON RESIDUALS

Table A2. *Cont.*

MEAN = −0.4711E−01
ST.DEV. = 0.4233E+00
OF MEAN
T-VALUE = −0.1113
NORMALITY TEST = 1.516 (CHI-SQUARED (2))
SKEWNESS = −0.5638 (SE = 0.4629)
KURTOSIS = 2.8329 (SE = 0.9258)

SUM OF SQUARES = 0.1405E+03
DURBIN–WATSON = 1.9335
STANDARD DEVI. = 0.2651E+01
OF RESID.
VARIANCE = 0.7026E+01
OF RESID.

AUTOCORRELATIONS OF RESIDUAL

	−0.0239	0.0514	−0.0728	0.0292	0.1018	−0.0367
SE	0.1890	0.1891	0.1896	0.1906	0.1907	0.1927
	−0.0842	−0.2723	0.0634	−0.0344	0.0437	−0.1325
SE	0.1929	0.1942	0.2074	0.2081	0.2083	0.2086
	−0.0027	0.0900	0.0348	−0.1867	0.0267	−0.0489
SE	0.2116	0.2116	0.2130	0.2132	0.2190	0.2191

THE LJUNG–BOX Q VALUE IS 8.44
IF RESIDUALS ARE RANDOM, IT SHOULD BE DISTRIBUTED AS CHI-SQUARED (14)

INPUT PARAMETERS

LAM = 1	IMEAN = 1	RSA = 0	MQ = 4
P = 0	BP = 0	Q = 1	BQ = 1
D = 1	BD = 1	NOADMISS = 1	RMOD = 0.500
M = 23	QMAX = 36	BIAS = 1	SMTR = 0
THTR = −0.400	MAXBIAS = 0.500	IQM = 16	OUT = 1
EPSPHI = 2.000	MAXIT = 20	XL = 0.990	SEK = 3.000

TRANSFORMATION: Z → Z
NONSEASONAL DIFFERENCING D = 1
SEASONAL DIFFERENCING BD = 1

DIFFERENCED SERIES

YEAR	1ST	2ND	3RD	4TH
2013	5.459	1.347	3.299	
2014	4.049	0.398	0.444	1.697
2015	1.869	−1.361	2.057	2.748
2016	−7.516	2.504	−4.479	4.937
2017	5.897	−1.761	4.256	−2.174
2018	1.969	2.471	1.600	−4.382

SERIES HAS BEEN MEAN CORRECTED

Table A2. *Cont.*

DIFFERENCED AND CENTERED SERIES

YEAR	1ST	2ND	3RD	4TH
2013	4.358	0.246	2.198	
2014	2.948	−0.703	−0.657	0.596
2015	0.768	−2.462	0.956	1.647
2016	−8.617	1.403	−5.580	3.836
2017	4.796	−2.862	3.155	−3.275
2018	0.868	1.370	0.499	−5.483

MEAN OF DIFFERENCED SERIES 0.1101E+01

VARIANCE OF Z SERIES = 0.1188E+04

VARIANCE OF DIFFERENCED SERIES = 0.1091E+02

AUTOCORRELATIONS OF STATIONARY SERIES

	−0.2790	0.1059	0.0428	−0.2485	0.1982	−0.0861
SE	0.2085	0.2242	0.2263	0.2267	0.2382	0.2453
	0.0100	−0.1925	0.0074	−0.0569	0.0277	0.0559
SE	0.2466	0.2466	0.2531	0.2531	0.2536	0.2538
	−0.1045	0.1487	0.0480	−0.0832	0.0882	−0.0228
SE	0.2543	0.2562	0.2599	0.2603	0.2614	0.2627

PARTIAL AUTOCORRELATIONS

	−0.2790	0.0304	0.0868	−0.2388	0.0738	0.0231
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085
	−0.0148	−0.2932	−0.0428	−0.0584	0.0085	−0.0450
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085
	−0.0546	0.0925	0.1576	−0.1486	−0.0489	0.0870
SE	0.2085	0.2085	0.2085	0.2085	0.2085	0.2085

MODEL FITTED

NONSEASONAL P = 0 D = 1 Q = 1
SEASONAL BP = 0 BD = 1 BQ = 1
PERIODICITY MQ = 4

20 ITERATIONS COMPLETED
58 FUNCTION VALUES F = 0.18578351E+03
0.276250E+00 0.940575E+00

Table A2. *Cont.*

PARAMETERS FIXED
0

PARAMETER ESTIMATES

MEAN = 1.10122

SE = 0.226077

CORRELATION MATRIX

1
0.141 1.000

ARIMA PARAMETERS

THETA = −0.2762
SE = 0.1965

BTHETA= −0.9406
SE = 0.1811

RESIDUALS

YEAR	1ST	2ND	3RD	4TH
2012	0.482	−1.680	0.642	−2.966
2013	−1.520	2.233	1.902	−0.233
2014	2.225	2.406	1.217	0.218
2015	2.981	0.046	1.488	1.947
2016	−5.332	−0.801	−4.414	4.061
2017	0.397	−2.121	−1.375	1.312
2018	0.548	−0.577	−0.403	−4.003

TEST-STATISTICS ON RESIDUALS

MEAN = −0.4711E−01
ST.DEV. = 0.4233E+00
OF MEAN
T-VALUE = −0.1113

NORMALITY TEST = 1.516 (CHI-SQUARED (2))
SKEWNESS = −0.5638 (SE = 0.4629)
KURTOSIS = 2.8329 (SE = 0.9258)

SUM OF SQUARES = 0.1405E+03

Table A2. *Cont.*

DURBIN–WATSON = 1.9335

STANDARD DEVI. = 0.2651E+01
OF RESID.
VARIANCE = 0.7026E+01
OF RESID.

AUTOCORRELATIONS OF RESIDUAL

	−0.0239	0.0514	−0.0728	0.0292	0.1018	−0.0367
SE	0.1890	0.1891	0.1896	0.1906	0.1907	0.1927
	−0.0842	−0.2723	0.0634	−0.0344	0.0437	−0.1325
SE	0.1929	0.1942	0.2074	0.2081	0.2083	0.2086
	−0.0027	0.0900	0.0348	−0.1867	0.0267	−0.0489
SE	0.2116	0.2116	0.2130	0.2132	0.2190	0.2191

THE LJUNG–BOX Q VALUE IS 8.44
IF RESIDUALS ARE RANDOM, IT SHOULD BE DISTRIBUTED AS CHI-SQUARED (14)

APPROXIMATE TEST OF RUNS ON RESIDUALS

NUM.DATA = 28
NUM. (+) = 14
NUM. (−) = 14
T-VALUE = 0.385

AUTOCORRELATIONS OF SQUARED RESIDUAL

	−0.0519	0.1505	0.1234	−0.0679	−0.2469	−0.1222
SE	0.1890	0.1895	0.1937	0.1965	0.1973	0.2081
	−0.1180	−0.1166	0.0266	−0.0928	0.2000	−0.0806
SE	0.2106	0.2130	0.2152	0.2154	0.2168	0.2233
	0.1145	−0.1318	0.0713	−0.1000	−0.0715	−0.0202
SE	0.2243	0.2264	0.2291	0.2299	0.2315	0.2322

THE LJUNG–BOX Q VALUE IS 10.46
IF RESIDUALS ARE RANDOM, IT SHOULD BE DISTRIBUTED AS CHI-SQUARED (14)

BACKWARD RESIDUALS

YEAR	1ST	2ND	3RD	4TH
2012	1.855	−0.263	3.303	−0.139
2013	−2.972	−1.407	0.377	−3.037
2014	−2.271	−0.984	−0.275	−3.383
2015	−0.019	−1.852	0.468	5.494
2016	−0.278	2.498	−4.809	1.393
2017	2.060	0.168	−1.976	0.231

Table A2. *Cont.*

2018	1.005	1.161	3.374	−1.040	
SECOND PART: DERIVATION OF THE MODELS FOR THE COMPONENTS					
SERIES TITLE: GDP					
MODEL PARAMETERS (0,1,1) (0,1,1)					
PARAMETER VALUES PASSED FROM ARIMA ESTIMATION (TRUE SIGNS)					
THETA PARAMETERS 1.00 −0.28					
BTHETA PARAMETERS					
1.00	0.00	0.00	0.00	−0.94	
PHI PARAMETERS 1					
BPHI PARAMETERS 1					
NUMERATOR OF THE MODEL					
1.0000	−0.2762	0.0000	0.0000	−0.9406	0.2598
STATIONARY AUTOREGRESSIVE TREND-CYCLE 1					
NON-STATIONARY AUTOREGRESSIVE TREND-CYCLE					
1.0000	−2.0000	1.0000			
AUTOREGRESSIVE TREND-CYCLE					
1.0000	−2.0000	1.0000			
STATIONARY AUTOREGRESSIVE TRANSITORY COMP. 1					
NON-STATIONARY AUTOREGRESSIVE TRANSITORY COMP. 1					
AUTOREGRESSIVE TRANSITORY COMP. 1					
STATIONARY AUTOREGRESSIVE SEASONAL COMPONENT 1					
NON-STATIONARY AUTOREGRESSIVE SEASONAL COMPONENT					
1.0000	1.0000	1.0000	1.0000		
AUTOREGRESSIVE SEASONAL COMPONENT					
1.0000	1.0000	1.0000	1.0000		
STATIONARY AUTOREGRESSIVE SEASONALLY ADJUSTED COMPONENT 1					
NON-STATIONARY AUTOREGRESSIVE SEASONALLY ADJUSTED COMPONENT					
1.0000	−2.0000	1.0000			

Table A2. *Cont.*

AUTOREGRESSIVE SEASONALLY ADJUSTED COMPONENT

1.0000	−2.0000	1.0000

TOTAL DENOMINATOR

1.0000	−1.0000	0.0000	0.0000	−1.0000	1.0000

MA ROOTS OF TREND-CYCLE

REAL PART	IMAGINARY PART	MODULUS	ARGUMENT (DEG.)	PERIOD
0.985	0.000	0.985	0.000	-
−1.000	0.000	1.000	180.000	2.0

TOTAL SQUARED ERROR = 0.3830257E−32

MA ROOTS OF SEAS.

REAL PART	IMAGINARY PART	MODULUS	ARGUMENT (DEG.)	PERIOD
−0.525	0.522	0.740	135.201	2.663
1.000	0.000	1.000	0.000	-

TOTAL SQUARED ERROR = 0.5704740E−36

MA ROOTS OF SEASONALLY ADJUSTED SERIES

REAL PART	IMAGINARY PART	MODULUS	ARGUMENT (DEG.)	PERIOD
0.276	0.000	0.276	0.000	-
0.985	0.000	0.985	0.000	-

TOTAL SQUARED ERROR= 0.2770076E−30

MODELS FOR THE COMPONENTS

TREND-CYCLE NUMERATOR

1.0000	0.0152	−0.9848

TREND-CYCLE DENOMINATOR

1.0000	−2.0000	1.0000

INNOV. VAR. (*) 0.12513

SEAS. NUMERATOR

1.0000	0.0506	−0.5026	−0.5480

SEAS. DENOMINATOR

1.0000	1.0000	1.0000	1.0000

INNOV. VAR. (*) 0.00036

IRREGULAR
VAR. 0.38326

Table A2. *Cont.*

SEASONALLY	ADJUSTED	NUMERATOR
1.0000	−1.2611	0.2721
SEASONALLY	ADJUSTED	DENOMINATOR
1.0000	−2.0000	1.0000
INNOV. VAR. (*)		0.95557

(*) IN UNITS OF VAR (A)

MOVING AVERAGE REPRESENTATION OF ESTIMATORS (NONSTATIONARY)

The last column (the sum of the Psi-Weights) should be zero for negative lags, 1 for lag = 0, and equal to the Box–Jenkins Psi-Weights for positive lags.
PSIEP (LAG), for example, represents the effect of the overall innovation a (t-lag) on the estimator of the trend for period t.
Similarly for the other components.

LAG	PSIEP	PSIES	PSIEC	PSIEA	PSIUE	PSIEP + PSIES + PSIUE
−8	−0.0043	0.0254	0.0000	−0.0254	−0.0211	0.0000
−7	−0.0022	0.0011	0.0000	−0.0011	0.0011	0.0000
−6	0.0047	−0.0088	0.0000	0.0088	0.0041	0.0000
−5	0.0039	−0.0188	0.0000	0.0188	0.0149	0.0000
−4	0.0017	0.0270	0.0000	−0.0270	−0.0286	0.0000
−3	0.0200	0.0012	0.0000	−0.0012	−0.0212	0.0000
−2	0.0859	−0.0093	0.0000	0.0093	−0.0766	0.0000
−1	0.2973	−0.0199	0.0000	0.0199	−0.2774	0.0000
0	0.5885	0.0282	0.0000	0.9718	0.3833	1.0000
1	0.7225	0.0013	0.0000	0.7225	0.0000	0.7238
2	0.7332	−0.0095	0.0000	0.7332	0.0000	0.7238
3	0.7440	−0.0202	0.0000	0.7440	0.0000	0.7238
4	0.7547	0.0284	0.0000	0.7547	0.0000	0.7832
5	0.7655	0.0013	0.0000	0.7655	0.0000	0.7668
6	0.7762	−0.0095	0.0000	0.7762	0.0000	0.7668
7	0.7870	−0.0202	0.0000	0.7870	0.0000	0.7668
8	0.7977	0.0284	0.0000	0.7977	0.0000	0.8262

WIENER–KOLMOGOROV FILTERS (ONE SIDE)

TREND-CYCLE COMPONENT

0.3582	0.2309	0.0674	0.0177	0.0014	0.0013
0.0038	0.0002	−0.0033	−0.0001	0.0032	0.0001
−0.0031	−0.0001	0.0030	0.0001	−0.0029	−0.0001
0.0028	0.0001	−0.0027	−0.0001	0.0027	0.0001
−0.0026	−0.0001	0.0025	0.0001	−0.0024	−0.0001
0.0024	0.0001	−0.0023	−0.0001	0.0022	0.0000
−0.0021	0.0000	0.0021	0.0000	−0.0020	0.0000

Table A2. *Cont.*

0.0020	0.0000	−0.0019	0.0000	0.0018	0.0000
−0.0018	0.0000	0.0017	0.0000	−0.0017	0.0000
0.0016	0.0000	−0.0016	0.0000	0.0015	0.0000
		SA SERIES COMPONENT			
0.9775	0.0075	0.0074	0.0073	−0.0216	0.0071
0.0070	0.0069	−0.0203	0.0067	0.0066	0.0065
−0.0191	0.0063	0.0062	0.0061	−0.0180	0.0059
0.0058	0.0057	−0.0169	0.0056	0.0055	0.0054
−0.0159	0.0052	0.0051	0.0051	−0.0150	0.0049
0.0048	0.0048	−0.0141	0.0046	0.0046	0.0045
−0.0132	0.0043	0.0043	0.0042	−0.0125	0.0041
0.0040	0.0040	−0.0117	0.0038	0.0038	0.0037
−0.0110	0.0036	0.0036	0.0035	−0.0104	0.0034
0.0034	0.0033	−0.0097	0.0032	0.0032	0.0031
		SEASONAL COMPONENT			
0.0225	−0.0075	−0.0074	−0.0073	0.0216	−0.0071
−0.0070	−0.0069	0.0203	−0.0067	−0.0066	−0.0065
0.0191	−0.0063	−0.0062	−0.0061	0.0180	−0.0059
−0.0058	−0.0057	0.0169	−0.0056	−0.0055	−0.0054
0.0159	−0.0052	−0.0051	−0.0051	0.0150	−0.0049
−0.0048	−0.0048	0.0141	−0.0046	−0.0046	−0.0045
0.0132	−0.0043	−0.0043	−0.0042	0.0125	−0.0041
−0.0040	−0.0040	0.0117	−0.0038	−0.0038	−0.0037
0.0110	−0.0036	−0.0036	−0.0035	0.0104	−0.0034
−0.0034	−0.0033	0.0097	−0.0032	−0.0032	−0.0031
		IRREGULAR COMPONENT			
0.6193	−0.2235	−0.0600	−0.0104	−0.0230	0.0058
0.0032	0.0067	−0.0171	0.0067	0.0034	0.0064
−0.0160	0.0063	0.0032	0.0060	−0.0151	0.0060
0.0030	0.0057	−0.0142	0.0056	0.0028	0.0053
−0.0133	0.0053	0.0026	0.0050	−0.0125	0.0050
0.0025	0.0047	−0.0118	0.0047	0.0023	0.0044
−0.0111	0.0044	0.0022	0.0042	−0.0104	0.0041
0.0021	0.0039	−0.0098	0.0039	0.0019	0.0037
−0.0092	0.0037	0.0018	0.0035	−0.0087	0.0034
0.0017	0.0033	−0.0082	0.0032	0.0016	0.0031

AUTOCORRELATION FUNCTION OF COMPONENTS (STATIONARY TRANSFORMATION)

	TREND-CYCLE			ADJUSTED		
LAG	COMPONENT	ESTIMATOR	ESTIMATE	COMPONENT	ESTIMATOR	ESTIMATE
1	0.000	0.367	0.369	−0.602	−0.602	−0.611
2	−0.500	−0.386	−0.419	0.102	0.099	0.174
3	0.000	−0.338	−0.335	0.000	0.018	−0.081
4	0.000	−0.118	0.088	0.000	−0.030	0.050
VAR. (*)	0.247	0.072	0.051	2.546	2.470	1.871

Table A2. *Cont.*

(*) IN UNITS OF VAR (A)

AUTOCORRELATION FUNCTION OF COMPONENTS (STATIONARY TRANSFORMATION)

	IRREGULAR			SEASONAL		
LAG	COMPONENT	ESTIMATOR	ESTIMATE	COMPONENT	ESTIMATOR	ESTIMATE
1	0.000	−0.361	−0.393	0.193	−0.152	−0.074
2	0.000	−0.097	−0.018	−0.341	−0.677	−0.617
3	0.000	−0.017	−0.132	−0.352	−0.170	−0.346
4	0.000	−0.037	0.011	0.000	0.966	0.697
VAR. (*)	0.383	0.237	0.176	0.001	0.000	0.000

(*) IN UNITS OF VAR (A)

For all components it should happen that:
-Var (Component) > Var (Estimator)
-Var (Estimator) close to Var (Estimate)

CROSSCORRELATION BETWEEN STATIONARY TRANSFORMATION OF ESTIMATORS

	ESTIMATOR	ESTIMATE
TREND/SEASONAL	−0.078	−0.331
SEASONAL/IRREGULAR	0.056	0.087
TREND-CYCLE/IRREGULAR	−0.106	−0.124

PSEUDO-INNOVATIONS IN THE COMPONENTS

PSEUDO INNOVATIONS IN TREND-CYCLE

YEAR	1ST	2ND	3RD	4TH
2012	0.49	0.67	0.29	0.07
2013	−0.26	−0.11	0.38	0.30
2014	−0.50	−0.14	0.56	0.87
2015	0.64	−0.32	−0.38	−0.57
2016	−0.58	−0.36	−0.62	−0.78
2017	−0.44	−0.32	−0.61	−0.24
2018	0.54	0.46	0.27	0.23

PSEUDO INNOVATIONS IN SEASONAL
X 10.0D−2

Table A2. *Cont.*

YEAR	1ST	2ND	3RD	4TH
2012	0.08	−0.06	−0.09	−0.11
2013	0.30	−0.05	−0.01	−0.21
2014	0.05	0.19	0.16	−0.19
2015	−0.46	0.40	0.10	0.16
2016	−0.59	0.33	0.15	−0.01
2017	−0.39	0.31	0.04	0.00
2018	−0.17	0.13	−0.12	0.07

PSEUDO INNOVATIONS IN SEASONALLY ADJUSTED SERIES

YEAR	1ST	2ND	3RD	4TH
2012	−1.04	3.39	1.13	0.95
2013	0.10	−1.84	0.20	2.08
2014	1.26	−4.81	2.56	−0.15
2015	5.46	0.12	−1.76	0.04
2016	−3.14	−0.54	−0.92	−2.14
2017	−2.89	0.18	−1.30	−2.88
2018	−0.06	3.18	−0.22	1.77

THIRD PART:
ERROR ANALYSIS

	FINAL ESTIMATION ERROR		REVISION IN CONCURRENT ESTIMATOR	
ACF (LAG)	TREND-CYCLE	ADJUSTED	TREND-CYCLE	ADJUSTED
1	0.636	−0.270	0.283	−0.247
2	0.172	−0.446	0.060	−0.439
3	0.048	−0.272	0.009	−0.283
4	0.017	0.958	0.020	0.941
VAR. (*)	0.139	0.010	0.097	0.011

TOTAL ESTIMATION ERROR (CONCURRENT ESTIMATOR)

ACF (LAG)	TREND-CYCLE	ADJUSTED
1	0.491	−0.259
2	0.126	−0.442
3	0.032	−0.278
4	0.018	0.950
VAR. (*)	0.236	0.021

(*) IN UNITS OF VAR (A)

VARIANCE OF THE REVISION ERROR (*)

Table A2. *Cont.*

ADDITIONAL	TREND-CYCLE PERIODS	ADJUSTED
0	0.9657E−01	0.1053E−01
4	0.4159E−03	0.9315E−02
8	0.3558E−03	0.8241E−02
12	0.3147E−03	0.7291E−02
16	0.2784E−03	0.6450E−02
20	0.2463E−03	0.5706E−02

PERCENTAGE REDUCTION IN THE STANDARD ERROR OF THE REVISION AFTER ADDITIONAL YEARS (COMPARISON WITH CONCURRENT ESTIMATORS)

AFTER 1 YEAR	93.44	5.924
AFTER 2 YEAR	93.93	11.51
AFTER 3 YEAR	94.29	16.77
AFTER 4 YEAR	94.63	21.72
AFTER 5 YEAR	94.95	26.37

VARIANCE OF THE REVISION ERROR FOR THE SEASONAL COMPONENT (ONE YEAR AHEAD ADJUSTMENT)

PERIODS AHEAD	VARIANCE (*)
0	0.1053E−01
1	0.1132E−01
2	0.1132E−01
3	0.1141E−01
4	0.1182E−01

AVERAGE PERCENTAGE REDUCTION IN RMSE FROM CONCURRENT ADJUSTMENT 2.828

(*) IN UNITS OF VAR (A)

DECOMPOSITION OF THE SERIES: RECENT ESTIMATES

Table A2. *Cont.*

PERIOD	SERIES	TREND-CYCLE			ADJUSTED		
		ESTIMATE	STANDARD ERROR		ESTIMATE	STANDARD ERROR	
			TOTAL OF REVISION			TOTAL OF REVISION	
−8	474.0	472.2	0.9902	0.5000E−01	473.9	0.3628	0.2406
−7	478.6	478.1	0.9902	0.5125E−01	478.8	0.3690	0.2499
−6	482.8	483.3	0.9902	0.5159E−01	482.7	0.3690	0.2499
−5	488.3	489.2	0.9903	0.5305E−01	488.2	0.3698	0.2509
−4	496.6	496.0	0.9904	0.5406E−01	496.5	0.3731	0.2558
−3	503.2	502.9	0.9904	0.5424E−01	503.4	0.3799	0.2656
−2	509.8	509.5	0.9918	0.7582E−01	509.7	0.3799	0.2657
−1	516.9	515.9	1.018	0.2400	516.8	0.3807	0.2668
0	520.8	522.3	1.287	0.8237	520.8	0.3843	0.2720

STANDARD ERROR OF 0.9889 0.2716
FINAL ESTIMATOR

PERIOD	SEASONAL		
	ESTIMATE	STANDARD ERROR	
		TOTAL OF REVISION	
−8	0.7847E−01	0.3628	0.2406
−7	−0.2377	0.3690	0.2499
−6	0.1058	0.3690	0.2499
−5	0.5415E−01	0.3698	0.2509
−4	0.7434E−01	0.3731	0.2558
−3	−0.2353	0.3799	0.2656
−2	0.1075	0.3799	0.2657
−1	0.5713E−01	0.3807	0.2668
0	0.6937E−01	0.3843	0.2720

STANDARD ERROR OF 0.2716
FINAL ESTIMATOR

DECOMPOSITION OF THE SERIES: FORECAST

PERIOD	SERIES		TREND-CYCLE			ADJUSTED		
	FORECAST	S.E.	FORECAST	STANDARD ERROR		FORECAST	STANDARD ERROR	
				TOTAL OF REVISION			TOTAL OF REVISION	
1	529.4	2.651	529.7	2.022	1.764	529.7	2.604	2.590
2	537.9	3.272	537.8	2.785	2.604	537.8	3.233	3.221
3	546.3	3.793	546.2	3.396	3.249	546.2	3.772	3.762
4	555.0	4.251	554.9	3.927	3.801	554.9	4.256	4.248
5	563.6	4.731	563.9	4.408	4.295	563.9	4.703	4.695
6	573.2	5.149	573.1	4.852	4.750	573.1	5.122	5.115
7	582.7	5.535	582.6	5.270	5.177	582.6	5.520	5.513
8	592.5	5.897	592.4	5.668	5.581	592.4	5.901	5.895

Table A2. *Cont.*

PERIOD	SEASONAL		
	FORECAST	STANDARD ERROR TOTAL OF REVISION	
1	−0.2352	0.3916	0.2821
2	0.1082	0.3916	0.2821
3	0.5845E−01	0.3924	0.2832
4	0.6857E−01	0.3960	0.2882
5	−0.2352	0.4031	0.2979
6	0.1082	0.4031	0.2980
7	0.5845E−01	0.4039	0.2990
8	0.6857E−01	0.4075	0.3038

CONFIDENCE INTERVAL AROUND A SEASONAL COMPONENT OF 0

	FINAL ESTIMATOR		CONCURRENT ESTIMATOR	
CONFIDENCE	−0.5323	95% 0.5323 INTERVAL	−0.7533	0.7533
CONFIDENCE	−0.2816	70% 0.2816 INTERVAL	−0.3986	0.3986

SAMPLE MEANS

	COMPLETE	PERIOD	LAST	THREE	YEARS
SERIES	453.6	487.8			
TREND-CYCLE	453.6	488.0			
ADJUSTED	453.6	487.8			
SEASONAL	−0.9266E−04	−0.6442E−03			

STANDARD ERROR OF ALTERNATIVE MEASURES OF GROWTH
(NONANNUALISED GROWTH)

1. PERIOD TO PERIOD GROWTH OF THE SERIES
TREND-CYCLE SEASONALLY ADJ. SERIES

CONCURRENT ESTIMATOR	1.032	0.607
1—PERIOD REVISION	0.866 0.607	
2—PERIOD REVISION	0.848	0.606
3—PERIOD REVISION	0.847	0.602
4—PERIOD REVISION	0.847	0.590
5—PERIOD REVISION	0.847	0.589
6—PERIOD REVISION	0.847	0.589
7—PERIOD REVISION	0.847	0.585
8—PERIOD REVISION	0.847	0.574
FINAL ESTIMATOR	0.844	0.433

Table A2. *Cont.*

3. ACCUMULATED GROWTH OVER THE LAST QUARTER OF PREVIOUS YEAR

	CONCURRENT ESTIMATOR		FINAL ESTIMATOR	
	TREND-CYCLE	SEASONALLY ADJ. SERIES	TREND-CYCLE	SEASONALLY ADJ. SERIES
QUARTER 1	4.126	2.430	3.375	1.731
QUARTER 2	2.981	1.300	2.544	0.924
QUARTER 3	2.121	0.816	1.819	0.578
QUARTER 4	1.606	0.080	1.387	0.078

(CENTERED) ESTIMATOR OF THE PRESENT ANNUAL GROWTH

STANDARD ERROR	TREND-CYCLE	SEAS. ADJ. SERIES	ORIGINAL SERIES
CONCURRENT ESTIMATOR	3.378	3.792	3.793
FINAL ESTIMATOR	1.387	0.078	0.000

FOURTH PART:
ESTIMATES OF THE COMPONENTS (LEVELS)

ORIGINAL SERIES

YEAR	1ST	2ND	3RD	4TH
2012	413.498	412.485	414.295	412.108
2013	412.408	416.854	420.011	421.123
2014	425.472	430.316	433.917	436.726
2015	442.944	446.427	452.085	457.642
2016	456.344	462.331	463.510	474.004
2017	478.603	482.829	488.264	496.584
2018	503.152	509.849	516.884	520.822

SEASONAL COMPONENT

YEAR	1ST	2ND	3RD	4TH
2012	−0.249	0.107	0.090	0.052
2013	−0.250	0.109	0.086	0.056
2014	−0.248	0.108	0.077	0.064
2015	−0.246	0.106	0.067	0.075
2016	−0.243	0.105	0.056	0.078
2017	−0.238	0.106	0.054	0.074
2018	−0.235	0.107	0.057	0.069

STANDARD ERROR OF SEASONAL

YEAR	1ST	2ND	3RD	4TH
2012	0.384	0.381	0.380	0.380
2013	0.373	0.370	0.369	0.369
2014	0.363	0.360	0.359	0.359
2015	0.354	0.350	0.351	0.354

Table A2. *Cont.*

2016	0.359	0.359	0.360	0.363
2017	0.369	0.369	0.370	0.373
2018	0.380	0.380	0.381	0.384
		TREND-CYCLE		
YEAR	1ST	2ND	3RD	4TH
2012	413.036	412.993	413.008	413.045
2013	414.059	416.484	419.251	422.110
2014	425.690	429.697	433.544	437.620
2015	442.159	446.759	451.376	455.250
2016	458.230	461.593	466.251	472.235
2017	478.053	483.273	489.178	495.992
2018	502.902	509.544	515.871	522.287
YEAR	1ST	2ND	3RD	4TH
		STANDARD ERROR OF TREND-CYCLE		
YEAR	1ST	2ND	3RD	4TH
2012	1.287	1.018	0.992	0.990
2013	0.990	0.990	0.990	0.990
2014	0.990	0.990	0.990	0.990
2015	0.990	0.990	0.990	0.990
2016	0.990	0.990	0.990	0.990
2017	0.990	0.990	0.990	0.990
2018	0.990	0.992	1.018	1.287
		SEASONALLY ADJUSTED SERIES		
YEAR	1ST	2ND	3RD	4TH
2012	413.747	412.378	414.205	412.056
2013	412.658	416.745	419.925	421.067
2014	425.720	430.208	433.840	436.662
2015	443.190	446.321	452.018	457.567
2016	456.587	462.226	463.454	473.926
2017	478.841	482.723	488.210	496.510
2018	503.387	509.742	516.827	520.753
		STANDARD ERROR OF SEASONALLY ADJUSTED SERIES		
YEAR	1ST	2ND	3RD	4TH
2012	0.384	0.381	0.380	0.380
2013	0.373	0.370	0.369	0.369
2014	0.363	0.360	0.359	0.359
2015	0.354	0.350	0.351	0.354
2016	0.359	0.359	0.360	0.363
2017	0.369	0.369	0.370	0.373
2018	0.380	0.380	0.381	0.384
		IRREGULAR COMPONENT		
YEAR	1ST	2ND	3RD	4TH
2012	0.711	−0.615	1.197	−0.989
2013	−1.401	0.261	0.675	−1.044
2014	0.030	0.511	0.296	−0.958
2015	1.030	−0.438	0.642	2.317
2016	−1.643	0.633	−2.797	1.690
2017	0.787	−0.549	−0.969	0.518
2018	0.486	0.197	0.956	−1.534

Table A2. *Cont.*

* * PROCESSING COMPLETED * *

Source: own computation in Gretl software with TRAMO/SEATS packages based on Table 4.

Table A3. Decomposed data.

	GDP_sa	GDP_trcl	GDP_sh	GDP_tr	GDP_cl
2012: 1	413.7467	413.0358	0.710963	402.2078	10.82797
2012: 2	412.3777	412.9930	−0.615329	405.4412	7.55182
2012: 3	414.2048	413.0080	1.196818	408.6813	4.32666
2012: 4	412.0559	413.0448	−0.988877	411.9397	1.10506
2013: 1	412.6579	414.0590	−1.401126	415.2306	−1.17152
2013: 2	416.7454	416.4842	0.261177	418.5687	−2.08453
2013: 3	419.9254	419.2507	0.674750	421.9684	−2.71770
2013: 4	421.0667	422.1104	−1.043713	425.4424	−3.33200
2014: 1	425.7199	425.6900	0.029932	429.0018	−3.31186
2014: 2	430.2079	429.6965	0.511357	432.6558	−2.95931
2014: 3	433.8401	433.5442	0.295901	436.4113	−2.86717
2014: 4	436.6616	437.6197	−0.958071	440.2736	−2.65386
2015: 1	443.1896	442.1592	1.030441	444.2458	−2.08666
2015: 2	446.3210	446.7589	−0.437876	448.3298	−1.57094
2015: 3	452.0183	451.3762	0.642043	452.5259	−1.14968
2015: 4	457.5670	455.2503	2.316690	456.8336	−1.58321
2016: 1	456.5872	458.2304	−1.643155	461.2514	−3.02105
2016: 2	462.2256	461.5929	0.632724	465.7772	−4.18431
2016: 3	463.4536	466.2508	−2.797233	470.4068	−4.15596
2016: 4	473.9255	472.2352	1.690333	475.1333	−2.89807
2017: 1	478.8407	478.0533	0.787393	479.9473	−1.89398
2017: 2	482.7232	483.2727	−0.549497	484.8377	−1.56492
2017: 3	488.2099	489.1784	−0.968521	489.7920	−0.61358
2017: 4	496.5097	495.9916	0.518015	494.7968	1.19482
2018: 1	503.3873	502.9017	0.485551	499.8385	3.06322
2018: 2	509.7416	509.5441	0.197443	504.9040	4.64013
2018: 3	516.8269	515.8706	0.956241	509.9822	5.88847
2018: 4	520.7526	522.2870	−1.534376	515.0649	7.22214
	CTCO_sa	CTCO_trcl	CTCO_sh	CTCO_tr	CTCO_cl
2012: 1	2317.416	2880.126	−562.7096	2896.450	−16.32410
2012: 2	2914.208	2978.811	−64.6035	2977.155	1.65699
2012: 3	3395.349	3080.988	314.3607	3057.849	23.13869
2012: 4	3831.568	3171.839	659.7289	3138.525	33.31445
2013: 1	3727.643	3243.089	484.5538	3219.186	23.90319
2013: 2	2798.340	3303.945	−505.6046	3299.859	4.08558
2013: 3	3449.957	3368.921	81.0361	3380.586	−11.66452
2013: 4	2989.525	3441.254	−451.7288	3461.409	−20.15473
2014: 1	3593.142	3520.524	72.6185	3542.365	−21.84086
2014: 2	3630.493	3602.371	28.1229	3623.478	−21.10714
2014: 3	3107.970	3688.396	−580.4253	3704.757	−16.36174
2014: 4	3917.811	3783.659	134.1521	3786.201	−2.54144
2015: 1	3991.103	3880.790	110.3134	3867.794	12.99510
2015: 2	4588.140	3968.908	619.2323	3949.524	19.38453
2015: 3	4347.080	4041.723	305.3574	4031.381	10.34146
2015: 4	3800.301	4105.987	−305.6855	4113.373	−7.38662
2016: 1	3687.837	4177.612	−489.7751	4195.510	−17.89838
2016: 2	3988.728	4263.672	−274.9444	4277.801	−14.12876

Table A3. *Cont.*

2016: 3	4934.958	4353.976	580.9820	4360.240	−6.26352
2016: 4	4238.193	4437.923	−199.7303	4442.815	−4.89151
2017: 1	4526.111	4520.136	5.9752	4525.509	−5.37272
2017: 2	4633.583	4603.811	29.7721	4608.302	−4.49114
2017: 3	4192.518	4691.496	−498.9777	4691.171	0.32435
2017: 4	5088.036	4785.336	302.6994	4774.091	11.24555
2018: 1	5253.709	4874.685	379.0238	4857.035	17.65045
2018: 2	5120.690	4952.665	168.0252	4939.984	12.68093
2018: 3	4823.567	5025.900	−202.3331	5022.931	2.96884
2018: 4	4963.177	5102.613	−139.4358	5105.876	−3.26291

Source: own computation in Gretl software based on Table 4.

Table A4. Spectral analysis for CTCO and GDP.

	Periodogram for CTCO_cl		
	Number of observations = 28		
omega	scaled frequency	periods	spectral density
0.22440	1	28.00	57.010
0.44880	2	14.00	42.457
0.67320	3	9.33	267.32
0.89760	4	7.00	60.761
1.12200	5	5.60	52.130
1.34640	6	4.67	8.1813
1.57080	7	4.00	0.88524
1.79520	8	3.50	0.81654
2.01960	9	3.11	1.4170
2.24399	10	2.80	0.52653
2.46839	11	2.55	0.50149
2.69279	12	2.33	0.55875
2.91719	13	2.15	0.44997
3.14159	14	2.00	0.44093
	Periodogram for GDP_cl		
	Number of observations = 28		
omega	scaled frequency	periods	spectral density
0.22440	1	28.00	22.124
0.44880	2	14.00	10.838
0.67320	3	9.33	0.57519
0.89760	4	7.00	0.92954
1.12200	5	5.60	0.034227
1.34640	6	4.67	0.36354
1.57080	7	4.00	0.081006
1.79520	8	3.50	0.016806
2.01960	9	3.11	0.042768
2.24399	10	2.80	0.054130
2.46839	11	2.55	0.034768
2.69279	12	2.33	0.032412
2.91719	13	2.15	0.029733
3.14159	14	2.00	0.028376

Source: own computation in Gretl software based on Table 4.

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