POSSIBLE USE OF The Retropolation Method For Estimating Aggregated Indices On The Quarterly National Accounts

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Abstract

The effort to quickly establish reliable estimates for the values of the quarterly national accounts has led developed countries to attenuate direct statistical surveys as the primary data source in favour of modelling. A number of modelling methods utilise the relationship between an aggregated index on the national accounts and an index that is surveyed currently (quarterly or monthly). This paper presents assumptions and possibilities for the use of the retropolation method as one of the disaggregation methods.

Keywords: Quarterly national accounts , disaggregation methods, retropolation method

Introduction

The basic data of the national accounts are given by annual values of indices, or annual national accounts. They are predominantly based on extensive surveys. The substance and scope of these activities imply the viewpoint that the goal of executing the annual national accounts (by surveys) is to have at our disposal information *as reliable as possible*, even if the lead time for its acquisition may be rather long.

On the contrary, *the quarterly national accounts* are aimed at getting quarterly values of the respective aggregated indices *as quickly as possible*. In this sense, the same macroeconomic statistical model is concerned as for the annual account surveys but based on different methods for data survey and processing: short-term surveys, modelling, etc. The methods used must always be quick and representative. The current practice of the Czech Statistical Office is predominantly based on quarterly statistical surveys; preliminary estimates for the aggregated indices of resources and uses of the gross domestic product (GDP) are known within about 60 days from the end of the respective quarter, and quarterly accounts by industry within about 90 days from the end of the quarter. The first preliminary information on the GDP evolution in the past quarter is available on about the 45th day. In the developed member countries in the EU, these lead times are shorter (a preliminary estimate is known on the 20th to 30th day after the end of the quarter, and preliminary estimates for the aggregated indices of resources and uses of the gross domestic product on the 40th to 50th day after the end of the quarter). These conditions are reflected in Eurostat's requirements – a preliminary estimate of the GDP growth should be published by each member country within 30 days from the end of the quarter.

The only way to shorten the lead times for establishing and publishing the data on quarterly national accounts is to replace surveys with modelling, that is, the so-called direct methods with indirect ones. The *direct methods* are predominantly based on quarterly (and in theory even monthly) statistical surveys, possibly complemented with data from administrative data sources. On the contrary, the *indirect methods* make use of economic-mathematical and statistical methods, specifically those of regression and time series analyses.

The crucial point of indirect methods for estimating the quarterly values of the aggregated indices on the national accounts is to provide, as soon as possible, estimates of indices on the quarterly national accounts in the past quarter; at the same time, predictions of the aggregated indices for one or two quarters ahead should also be enabled at a satisfactory level of accuracy and reliability of such predictions. A quality criterion for such estimates should be based on their ability to provide a basis for preliminary estimates of the values on the annual national accounts[50], and ensuring minimal deviations from the annual national accounts based on year-long surveys. Therefore it is logical that basic considerations concerning the methods for the quarterly estimates should unfold from a relationship between the annual and quarterly indices, or annual and quarterly national accounts. One of the methods providing for that unity is that of *retropolation* (allocation) of annual index values to quarterly ones[51]. This allocation stems from a connection between annual values and a short-term surveyed, so-called reference index.

An indisputable advantage of the estimation methods based on the relationship between the reference and estimated aggregated indices is the

[50] The preliminary estimates of the values on the annual national accounts are based on the quarterly data because each annual value must be a sum of the corresponding quarterly ones. On the other hand. the data on the quarterly national accounts are subsequently reviewed as soon as the complete data of the annual national accounts have been published.

[51] The retropolation method, in its general form, is one of the disaggregation methods recommended by Eurostat – cf. Eurostat (1999).

fact that these methods are applicable to all types of indices. The goal of the present contribution is to show the way in which the retropolation method may be used to quickly estimate quarterly values of a chosen index on the quarterly national accounts.

Assumptions of and conditions for the use of the retropolation method

The retropolation method combines a short-term surveyed index (called reference index) with an index on the annual national accounts. This relationship is modelled by a regression function between the short-term surveyed index and the corresponding aggregated index on national accounts. This model will allow us not only to allocate the known annual values to individual quarters so that their sum equals the annual value, but also to estimate the value of the respective aggregated index for the current quarter, as well as to predicate its value for one or two quarters ahead.

The retropolation (or any other disaggregation) method cannot, however, be the only method used for estimating the values on the quarterly national accounts. The aggregated indices on the national accounts are governed by fixed horizontal and vertical constraints and, for certain aggregated indices, no suitable reference indices can be identified at all. The allocation method therefore must, from the mentioned viewpoint, be combined with other methods for establishing the quarterly values (such as the input-output tables, surveys, administrative data sources, etc.[52]). Neither can we expect to be able to estimate in the first step, for example, the gross domestic product with the aid of the indirect methods for estimating the quarterly aggregated indices. The model of the quarterly national accounts must be gradually filled with estimates of individual aggregated indices (final consumption, gross fixed capital formation, imports, exports, etc.) by product or industry and subsequently balance and tune up these estimates to provide us with reliable short-term information.

The main condition for using the retropolation model is identification of index pairs: *aggregated index on national accounts ↔ quarterly established index*, and the annual value's allocation or estimates of the quarterly value of the aggregated index are based on the evolution within the model. These considerations must obviously be based on the existence of a high-quality model for the allocation, as well as a good overview of the available short-term data.

[52] In each developed country where the indirect methods for estimating within the quarterly national accounts are used, a combination of methods is used as a rule, and one selected method is viewed as the principal one. For example, in France allocation of annual values prevails, while in the Netherlands the method based on quarterly input-output tables is the key one. In Canada both allocation and input-output tables are used and direct methods are applied as well.

Reference index

Using the retropolation methods anticipates that a suitable reference index be found from among those surveyed quarterly or monthly. Such indices must be searched for not only among those surveyed by the government statistical services, but also among those surveyed by other institutions, such as banks, professional associations, chambers of commerce, ministries, etc. A criterion for selection is the factual connection with the index on the quarterly national accounts and, above all, the ability to reflect short-term fluctuations in the evolution of the values of the index to be estimated. In general, a suitable reference index should meet the following requirements:

a) available quickly, easily and without excessive financial demands, i.e., it should be available as quickly as possible after the end of the period under assessment (month or quarter) and it should already be surveyed (not introduced as a newly surveyed one);

b) a sufficiently long time series of its values should be available; and

c) it should be manifestly related to the index to be estimated; it may be selected from among indices of a value or natural substance, absolute or relative, established directly or derived.

It is not a simple task to properly identify a suitable reference index. We have to look, from among the indices meeting the above-mentioned conditions, for an index that will best cover short-term evolution of the given index on the quarterly national accounts. The suitability of such an index must be monitored on a longer time scale and separately for each index on the quarterly national accounts whose values have been estimated by the retropolation method. Only then we can relax the requirement for directly surveying the respective indices on the quarterly national accounts and take their estimates based on the model instead. This stage requires thorough analytical work which must not be underestimated or neglected. When applying indirect methods, we need not only to create a formal statistical model but also to build up an entire system of short-term statistical data.

Retropolation model

The retropolation method based on allocation of an annual value into calendar quarters can, in general, be carried out in two modes:

- *with subsequent adjustment*: within the first step the preliminary estimates of the quarterly values are found; and the second step ensures that a sum of these quarterly values complies with the annual value[53],
- *without subsequent adjustment*: this method already ensures the compliance between the quarterly and annual values in the first step[54].

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[53] Cf., e.g., Dureau (1991), Bournay, Laroque (1979), and Nasse (1973).

In the present contribution, the variant with subsequent adjustment will be used. The retropolation method with subsequent adjustment is carried out in two steps:

- *allocation* of the aggregated index's annual value to quarterly ones on the basis of the conjunctural evolution of the reference index;
- *adjustment* of the quarterly values obtained in the first step, based on the rule that a sum of quarterly values in one year must be equal to the respective annual value.

The *allocation* stage is based on establishing a regression equation that represents the relationship between the national accounts aggregated index's annual value on the one hand and the annual value of the reference index, as reported in the regular quarterly surveys, on the other hand; or rather, one-quarter of the aggregated index's annual value and the average quarterly value of the reference short-term index. Let us denote

A_T – value of aggregated index in the year T $T = 1, 2, ..., N$,
$Z_{T,i}$ – value of index in the i-th quarter of the year T $i = 1, 2, 3, 4$, $T = 1, 2, ..., N$,
$\overline{Z}_T$ – average value of index Z in the year T $T = 1, 2, ..., N$,
where $\overline{Z}_T = \frac{1}{4}\sum_{i=1}^{4} Z_{T,i}$.

The simplest and most often used type of function is linear[55], that is

$$\frac{1}{4}A_T = a + b\overline{Z}_T , \qquad T = 1, 2, ..., N. \qquad (1)$$

The parameters are then estimated with the aid of the least-square method.

When the parameters of the function are known, an approximation of the aggregated indices quarterly values can be calculated because the conjunctural information is available on a quarterly basis:

$${}_RA_{T,i} = a + bZ_{T,i} , \qquad T = 1, 2, ..., N, i = 1, 2, 3, 4, \qquad (2)$$

where ${}_RA_{T,i}$ is an estimate of the aggregated index's quarterly value if its annual value is allocated according to the evolution of the short-term index. This procedure is repeated for all quarters for which the $Z_{T,i}$ values are available regardless of whether the annual value is or is not known, i.e., for the current quarter but also for one or two quarters ahead.

Establishing the values of ${}_RA_{T,i}$ represents just the first stage in the procedure connecting the quarterly and annual values. In general, the allocation described above leads to the aggregated index's quarterly values

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[54] Cf., e.g., Kozák, Hindls, Hronová (2000a).
[55] However, other regression functions can also be used.

such that their sum is not equal to the annual value of the given aggregated index, i.e.,

$$\sum_{i=1}^{4} {}_{R}A_{T,i} \neq A_T \cdot \qquad (3)$$

If the annual value of the aggregated index is known, the deviation E_T can be established, where

$$E_T = A_T - \sum_{i=1}^{4} {}_{R}A_{T,i}\,, \qquad T = 1, 2, ..., N. \qquad (4)$$

In other words, the compliance between the annual and quarterly accounts (i.e., the condition that the annual aggregated index equals a sum of the quarterly values) must be respected not only within one year but for the entire time series lasting N years.

The procedure for allocating the data is based on seasonally cleaned values of the Z index – the original idea of this procedure is an assumption that the relationships between quarterly values copy those valid between annual values. That is why the seasonal cleaning is applied to the original $Z_{T,i}$ values, not to the allocated ${}_{R}A_{T,i}$, values; namely, the allocation will improve if the $Z_{T,i}$ values express seasonal fluctuations of the index as little as possible.

The adjustment, i.e., the second stage, aims at dividing the deviation E_T, $T = 1, 2, ..., N$**,** among four quarters as uniformly as possible while not denying the structure of the estimate obtained at the first stage, and at the same time preserving continuous year-to-year flow of data (the latter condition would not be met if the deviation E_T were divided into four equal parts, which is also a possible approach). Different methods are used to carry out the adjustment[56]. One of them is to allocate the deviation based on a specific matrix operator **K**, which is represented by a matrix of dimensions [4 × 3], whose entries k_{ij} are defined by

$$\sum_{i=1}^{4} k_{i,1} = 0, \qquad \sum_{i=1}^{4} k_{i,2} = 4, \qquad \sum_{i=1}^{4} k_{i,3} = 0, \qquad \sum_{j=1}^{3} k_{i,j} = 1, \qquad i = 1, 2, 3, 4 \qquad (5)$$

The quarterly values of the deviations are then calculated by the formula

$$\begin{bmatrix} & \mathbf{K} & \end{bmatrix} \begin{bmatrix} \bar{e}_{T-1} \\ \bar{e}_T \\ \bar{e}_{T+1} \end{bmatrix} = \begin{bmatrix} e_{T,1} \\ e_{T,2} \\ e_{T,3} \\ e_{T,4} \end{bmatrix}, \qquad (6)$$

[56] Cf., e.g., Dureau (1991), Bournay, Laroque (1979), and Eurostat (1999)

where $\bar{e}_T = \frac{1}{4} E_T$ is the average (quarterly) deviation for T = 1, 2, ..., N, and $e_{T,i}$ is the allocated (quarterly) deviation.

The adjusted quarterly value of the aggregated index ${}_C A_{T,i}$ is calculated by the formula

$$ {}_C A_{T,i} = {}_R A_{T,i} + e_{T,i}, \qquad T = 1, 2, ..., N,\ i = 1, 2, 3, 4, \qquad (7)$$

In this way, estimates of the aggregated index's quarterly values are obtained such that they sum up to the annual value.

The matrix operator denoted by **K** meets the assumptions for uniform distribution of the distributed deviations in the sense of smoothing up the quarterly values; hence this operator can be utilised for allocating annual values to quarters in instances of less important indexes on the quarterly national accounts for which no suitable reference index can be identified. In other words, the allocation is then carried out in a single step without taking into account relationships to any reference indices.

Applications to data in the Czech Republic

As an example of applying the retropolation method we have made use of the Czech Statistical Office's data. The allocated index (the dependent variable) is the Gross Value Added for the industry in the Czech Republic and the reference index (the independent variable) is the monthly nominal gross wage in the same industry. Table 1 shows the annual values of the dependent variable, while Table 2 shows the quarterly values of the independent variable.

The variables are chosen this way to answer a question whether or not it is possible to estimate the Gross Value Added in industry with the aid of the retropolation method. In addition to the average wages, we have tested the possibility of using other indices as well, such as the number of employees, volume of the wages, volume of new orders, and others; nonetheless, the strongest relationship has been proven between Gross Value Added and the average wages. The fact that the quarterly values of the Gross Value Added are known will enable us to compare the estimates obtained within our model with the actual values of the Gross Value Added for industry in the Czech Republic (based on the direct methods currently utilised), assessing both quality of the chosen model and suitability of the reference index.

Table 1 Gross Value Added (GVA) of the industry in the Czech Republic (million CZK, current prices)

Year	GVA	Year	GVA
2005	915,252	2010	1,071,734
2006	1,014,944	2011	1,122,672
2007	1,102,465	2012	1,132,527
2008	1,135,417	2013	1,137,039
2009	1,067,352	2014	1,248,230

Source: www.czso.cz

Table 2 Monthly nominal gross wages in industry in the Czech Republic (CZK, current prices)

Year	Quarter	Wages	Year	Quarter	Wages	Year	Quarter	Wages
2005	1	16,378	2009	1	21,143	2009	1	24,053
	2	17,580		2	22,156		2	25,307
	3	17,488		3	22,171		3	24,697
	4	19,091		4	24,434		4	26,680
	Average	17,634		Average	22,476		Average	25,184
2006	1	17,471	2010	1	22,160	2009	1	25,009
	2	18,747		2	23,099		2	25,946
	3	18,490		3	22,883		3	25,175
	4	20,353		4	25,214		4	27,368
	Average	18,765		Average	23,339		Average	25,875
2007	1	18,818	2011	1	23,074			
	2	20,092		2	24,148			
	3	19,800		3	23,628			
	4	21,747		4	25,821			
	Average	20,114		Average	24,168			
2008	1	20,970	2012	1	23,971			
	2	21,781		2	24,889			
	3	21,183		3	24,141			
	4	22,919		4	26,766			
	Average	21,713		Average	24,942			

Source: www.czso.cz

Estimating the parameters by the least-square method, we obtained the following regression equation:

$${}_{R}A_{T,i} = 6.510 + 127{,}726.214\, Z_{T,i}$$

The quarterly values of the average wage will be substituted into this equation, which expresses the relationship between one-quarter of the aggregated index and the average value of the reference index. We thus obtain an approximation of the industry GVA's quarterly values but without the equality between the annual value and a sum of the quarterly values. The results are shown in Table 3.

Table 3 Gross Value Added in industry in the Czech Republic based on Formula (8) (million CZK, current prices)

Year	Quarter		Year	Quarter		Year	Quarter	
2005	1	234,348.2	2009	1	265,368.4	2013	1	284,315.3
	2	242,175.0		2	271,962.9		2	292,479.0
	3	241,577.6		3	272,064.8		3	288,507.8
	4	252,009.7		4	286,797.3		4	301,417.5
	Sum	970,110.5		Sum	1,096,193.4		Sum	1,166,719.7
2006	1	241,466.9	2010	1	271,991.0	2014	1	290,539.0
	2	249,771.1		2	278,104.0		2	296,639.0
	3	248,096.3		3	276,696.4		3	291,619.7
	4	260,226.8		4	291,870.8		4	305,896.5
	Sum	999,561.1		Sum	1,118,662.3		Sum	1,184,694.2
2007	1	250,236.7	2011	1	277,944.5			
	2	258,531.0		2	284,933.9			
	3	256,624.3		3	281,549.4			
	4	269,303.6		4	295,826.0			
	Sum	1,034,695.6		Sum	1,140,253.7			
2008	1	264,243.6	2012	1	283,778.8			
	2	269,526.6		2	289,759.4			
	3	265,631.6		3	284,890.0			
	4	276,934.9		4	301,976.6			
	Sum	1,076,336.8		Sum	1,160,404.7			

Source: www.czso.cz, authors' calculations

A sum of such estimated (allocated) values does not equal the annual value of the given aggregated index – GVA of the industry. The deviations between the aggregated index's annual values and sums of the allocated quarterly values are shown in Table 4.

Table 4 Allocated values and deviations of the Gross Value Added for the industry in the Czech Republic (million CZK, current prices)

Year	Annual value A_T	Sum $\sum_R A_{T,i}$	Deviation E_T	Average quarterly deviation $\bar{e}_T$
2005	915,252	970,110.5	-54,858.5	-13,714.6
2006	1,014,944	999,561.1	15,382.9	3,845.7
2007	1,102,465	1,034,695.6	67,769.4	16,942.3
2008	1,135,417	1,076,336.8	59,080.2	14,770.1
2009	1,067,352	1,096,193.4	-28,841.4	-7,210.3
2010	1,071,734	1,118,662.3	-46,928.3	-11,732.1
2011	1,122,672	1,140,253.7	-17,581.7	-4,395.4
2012	1,132,527	1,160,404.7	-27,877.7	-6,969.4
2013	1,137,039	1,166,719.7	-29,680.7	-7,420.2
2014	1,248,230	1,184,694.2	63,535.8	15,883.9

Source: www.czso.cz, authors' calculations

The quarterly deviation values will be determined with the aid of the **K** matrix operator, which fulfils the conditions (5). For example, for 2006 we get

$$\begin{vmatrix} 0.291 & 0.793 & -0.084 \\ -0.041 & 1.207 & -0.166 \\ -0.166 & 1.207 & -0.041 \\ -0.084 & 0.793 & 0.291 \end{vmatrix} \begin{vmatrix} -13{,}714.6 \\ 3{,}845.7 \\ 16{,}942.3 \end{vmatrix} = \begin{vmatrix} -2{,}364.5 \\ 2{,}391.6 \\ 6{,}223.8 \\ 9{,}131.9 \end{vmatrix}$$

For the first and last years the missing values of the average quarterly deviation will be replaced with zeros (the error caused by this approach will be the smallest). The results are shown in Table 5.

Table 5 Quarterly values of deviations (million CZK, current prices)

Year	Quarter		Year	Quarter		Year	Quarter	
2005	1	-11,198.7	2009	1	-434.2	2013	1	-9,246.5
	2	-17,191.9		2	-7,360.9		2	-11,307.1
	3	-16,711.2		3	-10,673.7		3	-8,450.5
	4	-9,756.6		4	-10,372.5		4	-676.5
	Sum	-54,858.5		Sum	-28,841.4		Sum	-29,680.7
2006	1	-2,364.5	2010	1	-11,032.5	2014	1	10,436.7
	2	2,391.6		2	-13,135.4		2	19,476.1
	3	6,223.8		3	-12,783.5		3	20,403.7
	4	9,131.9		4	-9,976.9		4	13,219.3
	Sum	15,382.9		Sum	-46,928.3		Sum	63,535.8
2007	1	13,313.7	2011	1	-6,314.2			
	2	17,839.9		2	-3,667.3			
	3	19,205.5		3	-3,072.0			
	4	17,410.3		4	-4,528.2			
	Sum	67,769.4		Sum	-17,581.7			
2008	1	17,248.5	2012	1	-6,182.5			
	2	18,329.7		2	-7,000.1			
	3	15,310.6		3	-7,378.2			
	4	8,191.3		4	-7,316.8			
	Sum	59,080.2		Sum	-27,877.7			

Source: www.czso.cz, authors' calculations

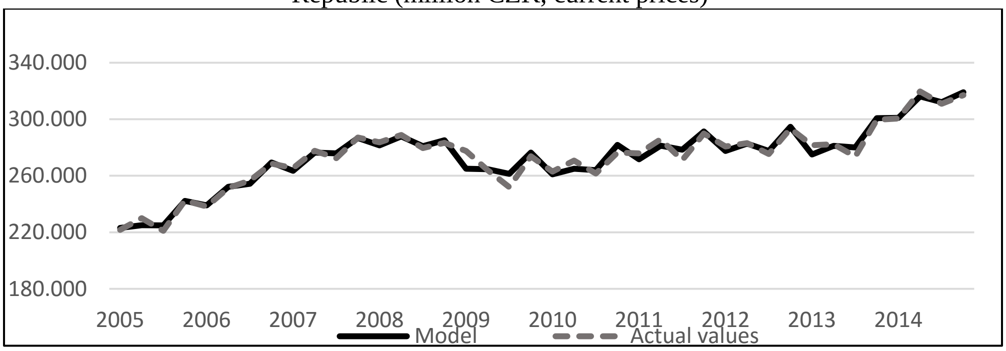
The estimated quarterly values of the Gross Value Added for the industry in the Czech Republic will then be obtained by summing up the values allocated within the first step (Table 3), and the allocated deviation values (Table 5). The results are shown in Table 6.

Table 6 Quarterly Gross Value Added of the industry in the Czech Republic (million CZK, current prices)

Year	Quarter	
2005	1	223,149.5
	2	224,983.1
	3	224,866.3
	4	242,253.1
	Sum	915,252.0
2006	1	239,102.5
	2	252,162.8
	3	254,320.1
	4	269,358.7
	Sum	1,014,944.0
2007	1	263,550.4
	2	276,370.9
	3	275,829.8
	4	286,713.9
	Sum	1,102,465.0
2008	1	281,492.1
	2	287,856.4
	3	280,942.3
	4	285,126.2
	Sum	1,135,417.0
2009	1	264,934.1
	2	264,601.9
	3	261,391.1
	4	276,424.8
	Sum	1,067,352.0
2010	1	260,958.5
	2	264,968.7
	3	263,912.9
	4	281,893.9
	Sum	1,071,734.0
2011	1	271,630.3
	2	281,266.5
	3	278,477.4
	4	291,297.8
	Sum	1,122,672.0
2012	1	277,596.2
	2	282,759.2
	3	277,511.7
	4	294,659.8
	Sum	1,132,527.0
2013	1	275,068.7
	2	281,171.9
	3	280,057.4
	4	300,741.0
	Sum	1,137,039.0
2014	1	300,975.7
	2	316,115.2
	3	312,023.4
	4	319,115.8
	Sum	1,248,230.0

The sums of the Gross Value Added quarterly values correspond with the annual values shown in Table 1, or Table 4. Chart 1 depicts a comparison between the model (Table 6) and actual values of the Gross Value Added for the industry in the Czech Republic. It turns out that both the selected model and the reference index meet the required conditions and enable us to properly estimate the industry's Gross Value Added quarterly values under the assumption of small turbulence. The model, however, was not able to cope with the economic stagnation in 2009; other, less significant changes in the dynamics of the Gross Value Added in the period from 2010 to 2014 are reflected relatively well.

Chart 1 Comparison of the actual and modelled GVA values of the industry in the Czech Republic (million CZK, current prices)



Source: www.czso.cz, authors' calculations

Within our research, we have carried out detailed calculations for other pairs of indices; our results confirm that the retropolation model is capable of providing good-quality quick estimates for indices on the quarterly national accounts. The use of the linear function at the first step has also been confirmed: this function's simplicity makes its use advantageous and the quality of the estimates is not injured. The adjustment at the second step could make use of other approaches, such as minimisation of deviations' squares[57] or other criteria as long as they ensure continuous year-to-year flow of data.

Conclusion

Modern state statistics could not do without utilisation of demanding statistical methods; this fact is also supported by the more-and-more demanding requirements of Eurostat with respect to the lead times for publishing the data on the quarterly national accounts. If reliable quarterly data are obtained quickly and efficiently, expenses incurred on their surveying are reduced and they bring about source information for improving our knowledge of the processes that take place in the national economy on a short-term scale. We should also point out the methodological point of view – it contributes to creating a set of methods compliant with the applicable standard valid for the national accounts.

The model presented in this paper enables us to efficiently estimate unknown values of indices on the quarterly national accounts. Of course, the selected method must not be the only one utilised for estimating the quarterly values; it should be complemented with other methods for such estimates (including the use of direct methods); indirect estimates of the quarterly values based on reference indices should not, at the same time, bring about a necessity of additional surveys. An indispensable tool when the quarterly national accounts are finally completed is the use of balance relationships on which the national accounts are based, as well as of expert estimates.

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