

Inflation measurement in times of large consumption shifts – Evidence of the CPI bias from Poland

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ABSTRACT

The paper addresses the problem of inflation measurement and the way it is affected by the choice of CPI weights. We focus on the bias resulting from using weights reflecting the past structure of consumption and the choice of the plutocratic index. The study is based on a comparison of the official consumer price index in Poland with superlative indices. Contrary to most literature, our findings indicate an understatement of the CPI. Additionally, in 2020 due to large changes in the pattern of household consumption, the underestimation increased. This results from the increase in the expenditure on the relatively more expensive goods which could not be accounted for in real time. In general, the lack of overstatement in the Polish CPI may result from frequent adjustments in the weights used for the calculation of CPI and a faster-than-CPI rise in the prices of those goods and services for which demand is relatively inelastic. Additionally, we deliver the estimates of the plutocratic gap, which indicates that the use of the plutocratic weights in the calculation of CPI leads to a lower price index than its democratic equivalent.

KEYWORDS

inflation, CPI bias, Laspeyres index, Fisher index, democratic index, consumption structure, COVID-19

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1. INTRODUCTION

The price index of consumer goods and services (CPI) is commonly used as the basic measure of inflation. It approximates the change in consumption expenditure that ensures a constant level of utility for households (COLI, Cost of Living Index; see e.g., [ILO 2004](#); [Diewert 1998](#)). The CPI calculation methodology in Poland is based on the Laspeyres formula with weights determined as the ratio of expenditure on a particular item to the total households' expenditures in the previous year. The choice of this formula is justified by the speed of the publication of such an index, as the data on the expenditures are available later than the data on prices. On the other hand, this method of construction of the index is not free from certain limitations. First, when collecting price data, it is difficult to keep up with the changes in consumers' behaviour (i.e., the substitution of goods with their cheaper equivalents) and account for the changing quality of the purchased goods or for the arrival of new goods in the market in the period between the weight-setting and the price survey. Second, the way the weights are established may lead to an overrepresentation of households with the highest total expenditures. Therefore, the CPI may be flawed with a certain bias, and thus, it may fail to fully reflect the changes in the cost of living. For this reason, economists attempt to approximate inflation with other indices regarded as the best approximation of the COLI (the so-called superlative or ideal indices).

The fact that this problem – by no means purely methodological, as it might seem – is given so much attention stems from the essential role of inflation in the economic processes. Failure to measure inflation accurately with the CPI may have a distorting influence on economic policy, including monetary policy.

This issue touches the more general problem of the quality of economic data and its accuracy, raised by [Morgenstern \(1963\)](#). Credibility of the data is of the utmost importance from the point of view of the policy makers as their decisions are based on the information that they are given as well as those that deal with the economic history. He points to this problem and recognizes several sources of errors that influence the quality of the economic data, including the consumer price index.

More recently, [Bagus \(2011\)](#) pointed out that instead of “trying to squeeze more out of the existing data” the economist should focus more on the data quality and sources of the potential errors. In turn, [Boumans \(2012\)](#) presented how the errors in social science were treated. Our paper follows this strand of the literature and focuses on one of the potential sources of errors mentioned by [Morgenstern \(1963\)](#), i.e., the lag between the time when the weights of the CPI items are collected and the time when their prices are included in the calculation of the CPI, the so-called substitution bias.

The correct measurement of inflation in monetary policy is particularly important in the countries where central banks are committed to inflation targeting. The European Central Bank (ECB) hinges its policy on the harmonized index of consumer prices (HICP). After targeting HICP to “remain below, but close to 2%”, in July 2021 the ECB introduced a symmetric inflation target of 2%. The positive value of the target was directly justified with an eventuality of an upward bias in the HICP indices ([ECB 2004](#)). This is in compliance with a widely accepted practice of central banks. As indicated by, among others, [Mishkin \(2001\)](#), [Meyer \(2002\)](#), [Kokoszcyński \(2004\)](#) and [Baranowski \(2008\)](#), a potential upward bias of the CPI estimates is one of the purely technical reasons for maintaining a positive inflation target.



The possible bias in the CPI may also affect those nominal quantities in the economy which are subject to indexation. This is of particular relevance in social policy, where the benefits (e.g., retirement pensions) are indexed using the CPI. The potential bias may also affect inflation expectations (Lanne et al. 2009; Łyziak – Mackiewicz-Łyziak 2014; Michalski 2022) and entrepreneurs' pricing decisions. Many theoretical models (e.g., Gali – Gertler 1999) looking into the pricing mechanisms and examining the nominal rigidities assume that some prices in the economy are subjected to indexation with the current inflation rate.

Since the 90s, economists have been trying to identify the sources of the CPI bias as well as estimating its size. Boskin et al. (1996), Cunningham (1996), Lequiller (1997), Crawford (1998), Ferenczi et al. (2002), Unayama (2004), Rossitier (2005) showed that in the stable, advanced economies the bias is usually small and positive. Large bias is usually found in cases of long periods of constant weights or during large shifts in the consumption patterns (Filer – Hanousek 2003).

In the case of Poland, the outcomes of the research are ambiguous. The estimates by Hałka – Leszczyńska (2011) indicate the understatement of the CPI in terms of the Fisher index; however, the substitution bias calculated by Białek (2014) points to a slight overstatement (by 0.00035 p.p.). Nonetheless, one has to keep in mind that firstly both studies were done on a different time period (respectively 2005–2009 and 2010–2013), and secondly, using different levels of CPI disaggregation.

Recently the problem of a correct measurement of inflation has resurfaced, as many countries faced a large shift in the consumption structure due to the outbreak of COVID-19 pandemics. In order to prevent the spread of coronavirus, many countries restricted certain activities, which led to a significant change in the consumption structure. The inability to purchase certain goods and services led to an increase in purchases of other, more available products (such as food prepared at home instead of a restaurant service). The bias resulting from COVID-19 restrictions (Cavallo 2020) is quite different from a well-documented substitution, new goods and quality bias. The shift in consumption is triggered by exogenous conditions rather than by changes in the relative prices (of different goods or different outlets).

In this paper, we focus on the consequences of using the structure of consumption from the past for the inflation measurement. We evaluate the bias resulting from such a lag. This is associated mainly with the product substitution bias and the effect of an exogenous consumption shift, such as the COVID-19 shock. In the empirical exercise we use over 300 price sub-indices of goods and services in Poland in the period of 2015–2020. We also focus on the changes in consumption patterns and their consequences for the magnitude of the substitution bias by examining the consumption structure in 2020 (largely affected by the COVID-19 pandemic). We also evaluate its consequences for the measurement of inflation.

The results show a slight understatement of the CPI stemming from the CPI product substitution bias. Such a downward bias effect is rather unusual compared to the results in other countries. On the one hand, the overstatement may be absent due to frequent adjustments in the weights used for CPI calculation in Poland. On the other hand, in the analysed period, there was a faster-than-CPI rise in the prices of those goods and services the demand for which is relatively inelastic (Table A1 in the Appendix). In addition, a positive growth of households' real income has been observed in this period. Furthermore, in 2020, due to the rapid changes in the households' consumption pattern the underestimation increased.

Apart from investigating the consequences of using lagged weights in the CPI calculation, we also examine how the method of weights' computation affect the level of the price index.



Prais (1959) stated that the CPI can be interpreted as the weighted average of price indices of respective households, with the weights determined by the share of a household's spending in the total expenditure of all households. Consumption patterns of households with higher overall spending are more strongly reflected in the CPI – hence the term “plutocratic”. In contrast, the democratic index is based on weights defined with the use of the arithmetic mean of the share of households' expenditure on a given item. If the consumption structure changes in step with the level of total spending, the plutocratic gap opens (Ley 2005).

With our dataset we also aim to evaluate the plutocratic gap in Poland in the period of 2015–2020 and find that throughout the period the plutocratic CPI for Poland was lower than the *democratic index*.¹ This is due to the fact that the prices of the products frequently bought by low-income households rose faster than those of the products purchased by the high-income households. What is important, due to the large consumption shift the *plutocratic gap* opened widely in 2020, leading to low-income households experiencing larger price increases.

The rest of the paper is structured as follows. Section 2 addresses potential sources of the CPI bias. In Section 3 we discuss the calculation methods employed in the estimations of the CPI bias in Poland in the period of 2015–2020. In Section 4 we provide data and the results of the study, and finally Section 5 concludes.

2. SOURCES OF THE CPI BIAS

An imprecise estimation of price changes in an economy can result from deficiencies in data collection methods and weight-based aggregation methods, the issue already raised by Morgenstern (1963). The reasons why the CPI diverges from the true COLI are pondered by many researchers (Boskin et al. 1996; Ducharme 1997; Diewert 1998, among others).

The Boskin Commission Report (1996) of the United States Senate already provided a detailed description of the potential CPI biases as well as an estimation of them. The authors considered four sources of bias: upper- and lower-level substitution, outlet and new goods bias. The upper-level substitution bias, also called the product bias, is connected with changes in the relative prices of components in the CPI basket. The product substitution bias in the CPI results from the usage of fixed weights or a Laspeyres type price index in the calculation of the CPI. An index computed in this manner will not account for the current changes in consumption. This means that the CPI computed with the Laspeyres formula may be biased. For this reason, economists attempt to approximate the CPI with other indices regarded as the best approximation of the COLI (the so-called superlative or ideal indices). The difference between the Laspeyres index and an ideal index will indicate the size of the CPI bias attributable to product substitution.

The lower-level substitution bias arises when the formula used at the lowest level of aggregation does not take into account substitution between similar items within a certain category (e.g., between different soap brands). The national statistical offices (NSO) can address it by applying the geometric

¹This finding does not mean that the CPI is biased per se, but this fact should be taken into consideration whenever the price index is needed for shaping the social policy.



mean when calculating indices at the lowest level of the data aggregation, as the geometric mean formula does not require quantity data (Dalton et al. 1998). Statistics Poland follows this recommendation; hence we can infer that the CPI in Poland is free from this bias.

The other types of bias are outlet substitution (results from substitution triggered by price differences between individual points of sale), new goods (effect of a lagged introduction of new goods to the CPI basket) and quality bias (outcome of the changes in the quality of examined consumer goods).

Recently, there arised an additional source of the CPI bias, connected with the COVID-19 pandemic and the restrictions imposed to combat it. The pandemic led to wide-spread lockdowns in many countries and the closure of non-essential retail outlets (clothing, furniture shops etc.) and services (hotels, restaurants, sport and personal care places), which resulted, among others, in an increased number of missing items and the necessity to impute their prices by the NSO as advised by The United Nations Economic Commission for Europe (UNECE 2020) and Eurostat (2020). According to Diewert – Fox (2020) such procedure led to a downward bias in the CPI. They call this the opposite of the new product problem – the item is available in the previous period, but not in the current one.

The inability to purchase certain products leads to a significant change in the household expenditure. Cavallo (2020) updated the CPI weights using high-frequency transactional data and calculated the “COVID-Basket CPI” for 18 countries. According to his estimates, the shift in the household consumption structure was not accounted for in the official CPI. He showed that inflation calculated with the updated weights was higher than the official index in 13 countries and lower in the remaining five. His results underline the importance of frequent updates of the weights in the CPI, especially in times of large changes in consumer behaviour. A recent work by Henkel et al. (2023) study the pandemic challenges for inflation measurement and analyse how price setting has reacted to the COVID-19 shock. Their analysis of micro price data (both scanner and web-scraped) show, among other results, that the euro area inflation rate in 2020 was subject to a downward measurement bias, due to the massive shift in the expenditure pattern.

As mentioned above, the methodology for CPI calculation faces the problem of assigning weights to the respective households. The weakness of the *plutocratic CPI* lies in the fact that it measures a change in the price of a consumption basket, which is dominated by higher-income households. As Prais (1959) indicated long-time ago, one of the methods to minimise this bias is to opt for the aforementioned democratic index; another one involves the use of weights representing a median household. The index constructed as a result of these modifications will be more accurate in capturing the changes in the cost of living incurred by a typical household.

Thus, the problem of the plutocratic index is not a merely statistical one. Its application has a strong influence on economic policy, which is why the choice of the plutocratic vs. democratic index may spark a heated public debate.

We did not mention this issue among the bias sources listed above, since it is difficult to consider it in terms of an error. The democratic index is just an alternative to the commonly used plutocratic index, which measures the inflation correctly from the perspective of the whole economy. However, an evaluation of the plutocratic gap offers an insight into the differences between households at different levels of income. Therefore, the democratic version of the CPI index may be useful in designing social policies.



3. EMPIRICAL METHODOLOGY

3.1. The superlative index

As mentioned in the previous part, substitution bias may result from the index formula applied, which is based on a pre-defined system of weights. This raises the question of which weight system should be used, and hence, what index calculation formula should be employed.

The literature of the index number theory presents several approaches to selecting the price index formula. The first approach (called the “fixed basket approach”, e.g., [Diewert 2002](#)) proposes using a fixed-structure consumer spending basket in the calculation ([Kokoszczynski 2004](#)). Since the index is meant to reflect the overall price change between the base and the current period, the weights should correspond with the expenditure structure of either of these. The indices calculated on this principle include:

the Laspeyres index:

$$P_t^L = \frac{\sum_{i=1}^n p_{i,t} \cdot q_{i,b}}{\sum_{i=1}^n p_{i,b} \cdot q_{i,b}} \quad (1)$$

and the Paasche index:

$$P_t^P = \frac{\sum_{i=1}^n p_{i,t} \cdot q_{i,t}}{\sum_{i=1}^n p_{i,b} \cdot q_{i,t}} \quad (2)$$

where p_i denotes the price of good i , q_i stands for the quantity of good i in the basket, while the t and b subscripts refer to, respectively, the current and the base period.

Due to their simple construction, the Laspeyres – Paasche indices are broadly applied in price index calculation.² It should be noted, however, that the changes in consumption structure in response to the price movements cause both of the indices to demonstrate a certain bias. The Laspeyres index, based on the consumption structure observed in the period preceding the price collection, may overstate actual inflation. On the other hand, the Paasche index may understate it, as the weights refer to the consumption structure already adjusted in response to price changes. It follows from the index number theory that in the case of a negative correlation between the price and the quantity of goods purchased (a demand response to a price change), the Laspeyres index will yield higher values than the Paasche index. Under a positive correlation the reverse is true ([ILO 2004](#)).

Since the Laspeyres index may overstate, and the Paasche index understate inflation, it can be inferred that the value of the COLI index will lie between those two indices. This gave rise to a proposal that the two indices should be averaged, or the weights should be calculated as a mean (whether arithmetic or geometric) of weights derived from the consumption structure of, respectively, the current and the base period. Such averaging of consumption structure is typical for superlative indices ([Boskin et al. 1996](#)). Examples of those indices include, among the others, the Fisher index, computed as a geometric mean of the Laspeyres – Paasche indices:

²In Poland, CPI is an example of a Laspeyres index, while the PPI is a Paasche index.



$$P_t^F = \sqrt{P_t^L \cdot P_t^P} \quad (3)$$

It should be noted, on the other hand, that consumer indices based on the current-period consumption structure may be announced with a considerable lag. This undercuts their utility in, for example, the conduct of monetary policy.

Another approach is the *axiomatic approach* (ILO 2004). It rests on the assumption that an ideal index should possess a range of well-defined characteristics (Fisher 1992). The indices which lack certain basic – or should we say fundamental – features should be rejected, as they may display undesirable properties (Diewert 1995). When analysed in terms of compliance with the respective characteristics, the indices can be ranked from the “best” to the “worst” ones. One should bear in mind that there is no agreement among researchers as to which qualities are the “best”. Thus, the axiomatic approach may lead us to more than one superlative price index.

The index fulfilling most of the properties is the one constructed by Fisher. The Paasche – Laspeyres indices fail the time reversal test (if the base and current periods switch places, the resultant index should equal the reciprocal of the original index). On the other hand, both boast a very useful quality: the consistency in multi-stage aggregation of individual indices.

Another method of choosing the index is the stochastic approach (weighted or unweighted, ILO 2004). It is based on the assumption that any price relationship can be regarded as an approximation to the inflation index. Indices based on the stochastic unweighted approach were proposed by Carli (does not satisfy the time reversal condition) and Jevons. However, researchers often emphasise the weakness of these indices resulting from the assumption that every price relationship is of equal importance. In the weighted approach, it is assumed that each price relation should be attributed a weight corresponding to its economic significance. An index based on this assumption is the Törnqvist – Theil index:

$$\ln P_t^T = \sum_{i=1}^n \frac{1}{2} (s_{i,t} + s_{i,b}) \ln \frac{p_{i,t}}{p_{i,b}}, \text{ where } s_{i,t} = \frac{q_{i,t} \cdot p_{i,t}}{\sum_{k=1}^n p_{k,t} \cdot q_{k,t}}, s_{i,b} = \frac{q_{i,b} \cdot p_{i,b}}{\sum_{k=1}^n p_{k,b} \cdot q_{k,b}} \quad (4)$$

As it possesses many relevant qualities, the Törnqvist – Theil index is deemed to be the superlative index based on the weighted stochastic approach (it also meets the time reversal condition; ILO 2004). On the other hand, it should be applied with a caution whenever individual price relations substantially deviate from the average level. In such a case, the value of the index will approach zero when the relations of individual prices are substantial or infinity when the relations are very small.

Yet another approach to constructing a superlative index is based on economic theory. It was developed by Konüs (1939) and rests on the assumption of consumers' optimising behaviour. With a given price vector p^t faced by consumers in period t , it is presumed that the basket of goods q^1 purchased by them complies with their utility function f (or the preferences). Each combination of preferred goods is represented by a continuous, non-decreasing, concave utility function. Thus, if the inequality $f(q^1) > f(q^0)$ is true, it follows that the consumer prefers the q^1 basket to the q^0 basket. By setting up that the consumer minimises the cost of attaining this utility in the current and base periods, we can observe that the true cost of living index is contained between the Laspeyres and the Paasche indices (Konüs 1939). If we further assume that the utility function is one of homothetic preferences, it can be proved that in terms of this



approach, the indices constructed by Fisher and Törnqvist – Theil, among others, are superlative.

Given the problems and issues above, many regard the Fisher index³ as the closest approximation to an actual inflation (Crawford 1998). Diewert (1998) indicates a range of characteristics displayed by the Fisher index which make it a good reflection of the actual COLI. However, Reinsdorf – Triplett (2009) highlight certain weaknesses of the tests which are supposed to evidence the superiority of the Fisher index over other indices: the tests are selected in an arbitrary manner and favour characteristics which the Fisher index happens to possess. Besides, they do not take into account the aggregation consistency, which, according to the authors, should characterise an ideal index. In spite of these reservations, the authors fail to propose any other index that would have an advantage over Fisher's.

In spite of their many strengths, in practice it is difficult to apply the Fisher as well as Törnqvist – Theil indices in measuring inflation. This is because they require data on the current structure of household consumption, which is not available at the time of calculating the index. In effect, national statistical authorities publish indices constructed with the weights based on past consumption patterns (the Laspeyres indices, the lag varies from one to a dozen years across countries), which can distort the index number. In order to recognise the size of the bias resulting from the substitution of goods, one can compare a price index calculated in line with the Laspeyres methodology with the superlative one.

The methodology used by Statistics Poland (2021) to calculate the CPI is based on the Laspeyres formula. The weight system is defined by the structure of expenditure incurred by households in the base year. Thus, it is a system of weights based on the value of goods and services purchased, computed as the product of their quantity and price. The data are derived from the annual household budget surveys and provide the basis for constructing a system of weights employed in the calculation of the CPI in Poland. With an eye on significant shifts in consumption structure, especially during the 1990s, Statistics Poland has been adjusting its weight system on an annual basis since 1990.

In the empirical part of the paper, we examine the difference between the consumer price index published by Statistics Poland and the index regarded as the best approximation of the COLI – the Fisher index. Additionally, we also calculate the Törnqvist – Theil index; however, taking into account the reservations mentioned above, we focus our attention on the Fisher index.

3.2. The democratic index

As mentioned earlier, the price index also depends on the manner in which household expenditure is averaged in the calculation of weights for individual goods in the consumer basket. The CPI as announced in Poland⁴ is a plutocratic one with the weights for the respective goods and services computed as a weighted average of the indices of individual households.

³In terms of the fixed-basket, axiomatic and economic approaches, it is called an ideal index.

⁴Many countries publish a range of CPIs relating to subsectors of the population such as all households, low income households or pensioner households etc., but a CPI based on democratic weights is very rare (ILO 2020). The general consensus states that the plutocratic index is better for the inflation measure or accounts deflators.



The weight of a given good i in the plutocratic index is defined as a share of spending on that good in the total expenditure by all the households. It can be illustrated with the following formula:

$$w_i^P = \frac{\sum_{k=1}^K e_{i,k}}{\sum_{i=1}^I \sum_{k=1}^K e_{i,k}} \quad (5)$$

where:

w_i^P – the plutocratic weight of a particular good i ,

$e_{i,k}$ – the expenditure of k -th household on a particular good i ,

The democratic index, in turn, is based on the weights defined as the arithmetic mean of the share of household expenditure on a given item, which can be described with the following formula:

$$w_i^D = \frac{1}{K} \sum_{k=1}^K \frac{e_{i,k}}{\sum_{i=1}^I e_{i,k}} \quad (6)$$

According to [Ley \(2005\)](#), there may be three contributions to the difference between the plutocratic and the democratic index. The first one is a difference in the distribution of expenditure across households. Next, the spending structure of individual agents within the respective expenditure brackets may differ. The third important factor is the varied behaviour of prices of the individual goods and services.

The difference between the plutocratic and democratic indices can be interpreted as the plutocratic gap. This should not be perceived as an error in estimating the CPI. Any evaluations concerning the superiority of either index in representing consumer price movements depend on the purposes for which the index is used ([Ruiz-Castillo et al. 2002](#); [Ley 2005](#)). The sign of the plutocratic gap will depend on the changes in relative prices of individual goods and services. The plutocratic index attaches more weight to luxury goods than to normal goods because the former holds a larger share in the overall spending. Hence, should prices of luxury goods rise more slowly than those of normal goods, the plutocratic index will turn out to be lower than the democratic one, opening a plutocratic gap. This implies that inflation affecting the lower-income households will be higher compared to inflation calculated on the basis of plutocratic weights.

[Ruiz-Castillo et al. \(2002\)](#) deliberate on the political consequences of using one or the other index. The central question posed by the authors is – which measure should be used for indexation of incomes, social transfers or tax brackets? Most countries opt for the CPI as a deflator for these values, which means that if the plutocratic gap is positive, the extent of indexation is smaller than it would be with the democratic index.

As [Ley \(2005\)](#) states, from the point of view of more affluent households, one of the most important values indexed with the CPI are tax brackets. Wherever inflation has a stronger impact on better-off households, indexation with the plutocratic CPI would mean the need to pay higher taxes (the adjustment of tax brackets would be smaller than the inflation experienced by this social group). In the converse situation, the CPI-based adjustment of tax brackets would result in relatively understated taxes to be paid by this group.

Apart from the above issues, both [Prais \(1959\)](#) and [Ley \(2005\)](#) point to a certain advantage of the plutocratic CPI over the democratic one. The CPI's strength lies in its simplicity of



calculation and consistency with the deflators computed on the basis of the national accounts. The plutocratic index – unlike the democratic one – can provide the answer to the question how much the national income should rise in order to offset the observed price change. In addition, [Prais \(1959\)](#) points to the information noise that could be generated if more than one price index were to be published.

4. DATA AND RESULTS

We estimated both the CPI bias and the plutocratic gap in Poland on data from 2015 to 2020. We use over 300 monthly price indices of goods and services (the so-called elementary groups) to calculate superlative indices (equations (3) and (4)). The weights for the computation of the plutocratic and democratic indices are calculated with equations (5) and (6) using individual data on the structure of household expenditure from the Household Budget Survey. When calculating each index (Laaspeyres, superlative, democratic and plutocratic) we implement the methodology used by [Statistics Poland \(2021\)](#). The source of all the data is Statistics Poland.

The result of the CPI bias evaluation is ambiguous, as the Fisher superlative index indicates understatement of the Polish CPI ([Table 1](#)), whereas an alternative, Törnqvist – Theil index, identifies on average a small overstatement of the Polish CPI. Such contradictory results were also reported in the study by [Hałka – Leszczyńska \(2011\)](#). However, as [Hill \(2006\)](#) and [Manser – McDonald \(1988\)](#) prove, the superlative indices approximate each other to the second order and do not necessarily render numerically identical results. In fact, the empirical differences between the superlative indices may be large. It is only the Fisher index, which is always contained between the Paasche and the Laspeyres indices.

Table 1. Estimated product bias (p.p.) and price indices (%), 2015–2020

Year	bias		Index		
	CPI-F	CPI-TT	CPI	Fisher	TT
2015	−0.03	0.09	−0.95	−0.92	−1.04
2016	−0.06	0.09	−0.59	−0.53	−0.68
2017	−0.07	0.03	1.98	2.05	1.95
2018	0.01	0.08	1.65	1.64	1.57
2019	−0.12	0.05	2.31	2.43	2.26
2020	−0.21	0.11	3.39	3.60	3.28
Avg. bias	−0.08	0.08			

Source: Statistics Poland, own calculations.

Note: Bias is calculated as the difference between the CPI and the Fisher (CPI-F) and Törnqvist – Theil (CPI-TT) index. The calculations were carried out with greater accuracy. The differences may result from rounding. The average bias was calculated based on the differences between the annual indices in the respective months during the years 2015–2020 (see also Appendix [Figure A1](#)).



When referring to the CPI bias, we compare the official CPI with the index calculated according to the Fisher method. There are several reasons for this. [Diewert \(1998\)](#) states that the Fisher index meets the largest number of requirements set by the axiomatic approach; at the same time, it complies with the revealed preference theory. Secondly, the literature of the subject points to the Fisher index as the best approximation of the COLI ([ILO 2004](#)). Yet another reason lies in the methodological considerations. Most surveys cited in the literature review of this paper are based on comparisons of the Laspeyres index with the Fisher index (see [Boskin et al. 1996](#); [Crawford 1998](#); [Filer – Hanousek 2003](#); [Rossiter 2005](#); [Unayama 2004](#)). By employing the same methodology, we ensure that the findings obtained for Poland are comparable to those for other countries.

The calculations we conducted using the Fisher index indicate an average CPI understatement of -0.08 p.p. in the analysed period ([Figure A1](#)). The bias is negative in every analysed year, except for 2018, and ranges from -0.12 p.p. to 0.01 p.p., which is a sign of an understatement of the Polish CPI. This result is consistent with earlier outcomes of [Hałka – Leszczyńska \(2011\)](#). On the other hand, [Białek \(2014\)](#) in a study for Poland points rather to overstatement of the CPI in the period of 2010–2013. Though one must keep in mind that apart from the different analysed period, [Białek \(2014\)](#) in his research used data on the higher level of the aggregation, which might have altered the results.

The review of the literature on CPI bias due to product substitution in other countries would suggest that the CPI is overstated. Thus, the results of our study are different to those for other economies and surprising in terms of the economic intuitions. In our opinion there are three possible explanations.

Firstly, the positive growth in the households' disposable income over the last 5 years indicates a real-term improvement in their financial standing. Additionally, consumer confidence in the analysed period was improving. In fact, the current consumer confidence indicator became positive in 2017, the first time since the survey was conducted ([Statistics Poland 2021a](#)). This positive tendency was reversed in April 2020 due to the outbreak of the COVID-19 pandemic. Thus, thanks to increasing disposable income, we can presume that households, in spite of rising prices of consumer goods and services, may not opt for cheaper substitutes (as they can afford more expensive ones), but will stick to the old consumption patterns. Furthermore, due to their expected good economic prospects, consumers may change their consumption pattern and start to consume goods of a higher quality, i.e., changing their consumption pattern for more expensive items.

Secondly, the analysis of relative price changes in the years 2015–2020 showed a larger-than-CPI rise in the prices of goods and services characterised by relatively rigid demand. This group comprises food, energy (electric power and heat energy) as well as housing services ([Appendix, Table A1](#)). The consumption of goods and services in this group is not reduced even in the face of considerable price rises. Actually, the weight of these items between 2015 and 2020 rose despite the fact that their prices also rose. When consumption structure is rigid, given the definition of the weights (value-based), there exists a positive relationship between the price growth and the change in weights – in contrast to the effect generated by the product bias. In this situation, the price index calculated according to the Fisher formula is higher than the index calculated with the Laspeyres methodology ([ILO 2004](#)).

Thirdly, in the countries where weights were updated less frequently, such as for example, four years in the case of Canada ([Crawford 1998](#)) or even 14 years for the US ([Boskin et al. 1996](#)), research finds the CPI to be overstated on account of the substitution bias (respectively, 0.1 and 0.4 p.p.). [Crawford \(1998\)](#) points out that more frequent weight updates (every 4 vs 6 years) lowered



the substitution bias in Canada by 0.1 p.p. In Poland the structure of weights is adjusted annually, which may be the reason why our study did not identify CPI bias attributable to this factor.

Additionally, in 2020 the magnitude of the understatement of the CPI has increased, which can be a result of two factors which sum-up to a larger downward CPI bias. The first one is connected with a large shift in the consumption of the households due to the COVID-19 pandemic and restrictions imposed on some economic activities. Year 2020 brought a substantial increase in expenditure on food and non-alcoholic beverages as well as housing and health, where inflation was higher than the overall CPI (see Figure 1). This implies that households did not fully substitute products whose prices are increasing with relatively cheaper ones, but instead increased their consumption. In such a situation, the index calculated according to the Paasche formula will be higher than the one using the Laspeyres formula, which results in an understatement of the CPI.

Second, during lockdowns the prices of some components could not be quoted by the NSOs because of the closure of several sectors of the economy, like clothing and footwear, transport (e.g., airline tickets), recreation and culture (e.g., theatre tickets, package holidays) as well as restaurants and hotels. According to the rules for the compilation of the consumer prices, statistical offices must ensure, among others, the stability of the weights in the CPI, and following the guidelines of the Eurostat (2020) and UNECE (2020), impute prices of the missing items. However, according to Diewert – Fox (2020) the practice to compile each subindex even when no product for some category is available on the market leads to a downward bias in the estimation of the CPI, which in the case of Poland deepened the downward bias.

In general, in all of the European Union (EU) countries the weights of the basic goods, such as food, services connected with housing, energy carriers and medical services in 2021⁵ were higher than before the COVID-19 pandemic. On the other hand, spending on hotels and

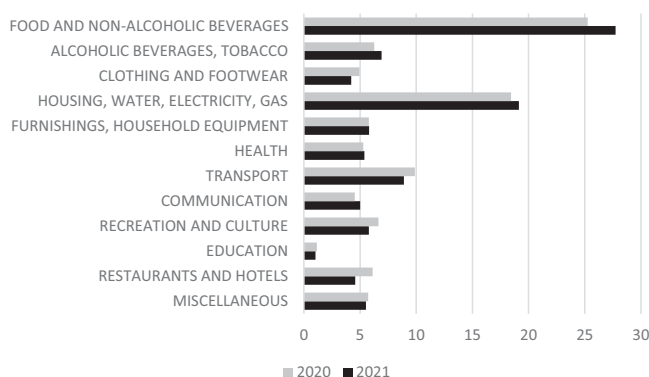


Fig. 1. Weights of the main CPI components in 2020 and 2021 (p.p.)

Source: Own calculations based on Statistics Poland data.

Note: Weights in 2020 are based on the 2019 expenditure structure, and in 2021 on the structure from 2020.

⁵Weights in 2021 are based on the consumption structure from 2020.



restaurants as well as recreational services declined. This change in the structure of consumer expenditure was forced by the imposition of restrictions on some of the economic activities.⁶ What is more, in the countries with a more severe government response to COVID-19, the changes were larger (see Figure 2).

The estimation of the superlative indices incidentally showed the fastest rise in the prices of goods, the demand for which is inelastic. These are the normal goods, whose share in the total expenditure is higher in the lower-income households. The rise in their relative prices should lead to the opening of a plutocratic gap.

In order to measure the plutocratic gap, indices were calculated using the same individual data from the Household Budget Surveys, but with different formulae: (5) and (6). The results are presented in Figure 3. The chart depicts the CPI development in two versions: a plutocratic

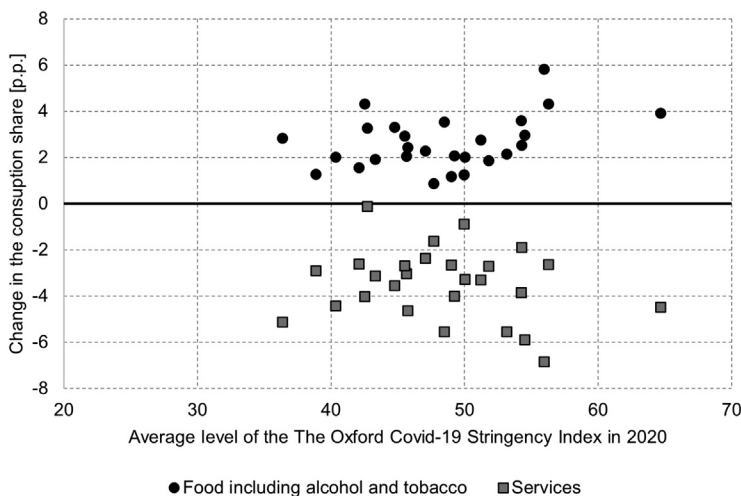


Fig. 2. Change in the consumption structure during COVID-19 pandemic in EU27 countries

Source: Eurostat, Hale et al. (2021).

Note: The change in the consumption structure is measured by the difference in 2021 HICP weight (representing the consumption structure from 2020⁷) of a given consumption component, relative to the 2020 weight (based on the 2019 consumption structure). Note that in index calculations in the empirical part of this paper we use the CPI weights. Here, the HICP weights are used in order to facilitate the international comparisons.

⁶The severity of restrictions is measured using the Oxford Stringency Index (Hale et al. 2021).

⁷The usual procedure of calculating HICP weights is to use the national accounts data from the year $t-2$. In normal times the changes between consecutive years are limited, therefore a two-year lag in the weighting system does not impose a significant difference in the price indices. However, in order to calculate weights for 2021, the Eurostat stressed the necessity to make the weights more representative of the consumption structure from 2020 (i.e., account for the shift in household expenditure caused by the COVID-19 pandemic) and indicated the urgency to utilize the data from the national accounts from 2020 as well as data from other data sources, e.g., short-term statistics on turnover in trade, transport, tourism and energy statistics (Eurostat 2020).



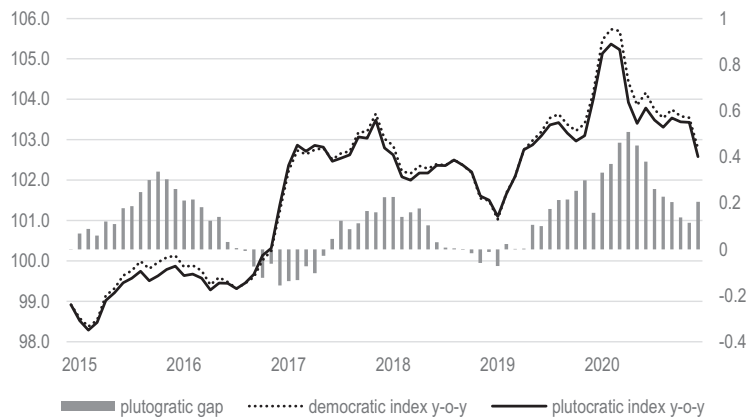


Fig. 3. Democratic and plutocratic price indices of consumer goods and services (%) and the plutocratic gap (p.p.), 2015–2020

Source: Statistics Poland, own calculations.

Note: The plutocratic index is close, but not equal to the CPI due to the corrections in the weighting scheme made by Statistics Poland.

index (the approach used by Statistics Poland) and a democratic one. It has to be underlined that the plutocratic index is close, but not equal to the CPI due to the corrections in the weighting scheme made by Statistics Poland.

The plutocratic gap is observed in the periods when the two indices diverge. This confirms the hypothesis of different consumption structures of households at different levels of overall spending.

The estimations of the plutocratic gap for Poland showed that the plutocratic index (an equivalent of the CPI) is lower than democratic one (on average by 0.13 p.p.). This is due to the fact that throughout the sample the components with larger democratic weights (see Figure 4,

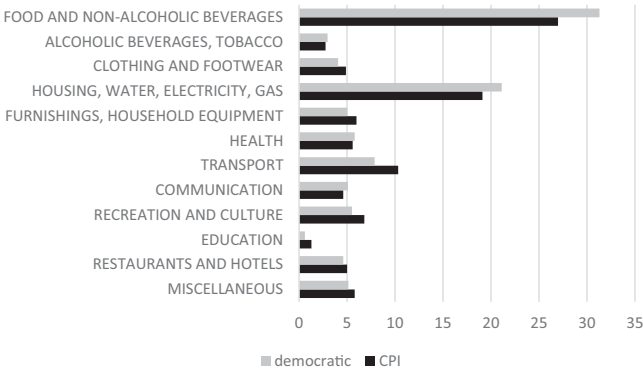


Fig. 4. Weights of the main CPI components in democratic and plutocratic indices, (p.p.) 2020

Source: Statistics Poland, own calculations.

Note: The differences are stable throughout the analyzed period.



Table 2. Average plutocratic gap (p.p.), democratic and plutocratic index (%), 2015–2020

Year	Plutocratic gap	Democratic index	Plutocratic index
2015	0.19	−0.56	−0.74
2016	0.04	−0.18	−0.22
2017	0.04	2.84	2.80
2018	0.06	2.23	2.16
2019	0.12	2.92	2.80
2020	0.30	4.19	3.88
Avg. gap	0.13		

Source: Statistics Poland, own calculations.

Note: The calculations were carried out with greater accuracy than presented in the table above. The differences may result from rounding. The average bias was calculated based on the differences between the annual indices in the respective months during the years 2015–2020.

Table 2) showed a higher inflation rate. Those components, are among others: food and non-alcoholic beverages, alcohol and tobacco, services connected with housing, including energy carriers and public transport. On the other hand, prices of clothing and footwear, recreation, restaurants (i.e., components with higher plutocratic weights) rose much slower than the average inflation rate. As a consequence, the democratic price index in the sample period was significantly higher. The difference was substantial, especially during 2020, in the period of high inflation. The plutocratic gap was also considerable during the deflation period, in 2015, however it was connected with large differences in the price dynamics of the energy goods. On the one hand, the fuel prices decreased much faster than the headline CPI, which lowered the inflation faced by the higher-income households. On the other hand, the prices of electricity (whose share in the consumption basket is higher for the low-income households) increased, which had an adverse effect. This shows that the plutocratic gap is not correlated with the level of the overall inflation rate, but depends on the differences in consumption structure and the differences in inflation dynamics across the consumption baskets.

What is more, in 2020 (when the massive shift in preferences occurred together with the distortions in the price collection) the plutocratic gap amounted to its maximum levels throughout the sample period. This may be the result of high food and housing prices accompanied by an unprecedented drop in the fuel prices. These price movements, together with substantial differences in the items' weights for households at different levels of income lead to an opening of the plutocratic gap. Eventually, we may conclude that in 2020 the low-income households experienced a higher inflation rate than the average household.

5. CONCLUSIONS

In the paper, we presented the problem of inflation measurement and the way it is affected by the choice of the CPI weights. We focused on the bias resulting from using weights reflecting the



past structure of consumption and the choice of plutocratic index. The empirical analysis was based on the Polish data. The first part of the paper is based on a comparison of the Laspeyres index (the officially published index) with superlative, Fisher index. The estimation aimed to examine how changes in consumption structure influence the CPI. This subject became more important given the recent consumption shift connected with the COVID-19 pandemic.

The second part of our study focused on the choice between the plutocratic and democratic weights in the calculation of the index. On the one hand, the plutocratic index has the advantage in terms of simplicity of calculation and consistency with the deflators estimated on the basis of the national accounts. On the other hand, it may have a distorting impact on social and fiscal policy as it underrepresents households with lower spending.

The research covering the period of 2015–2020, did not confirm the hypothesis of a positive CPI bias existing in Poland due to product substitution. In fact, the announced CPI is lower than the Fisher index, on average in the analysed period (by 0.08 p.p). Additionally, in 2020 due to a large shift in the consumption structure stemming from the COVID-19 pandemic, the magnitude of the understatement of the CPI has increased to 0.2 p.p. – which is in line with the euro area results reported by [Henkel et al. \(2023\)](#).

The absence of a positive substitution bias in Poland might seem as a surprising result. The first reason is the frequent weight adjustment which takes place every year, significantly reducing the risk of changes in the consumption structure being overlooked. Secondly, in Poland we observe positive growth in household disposable income and an improvement in the financial standing of households over recent years, which allows them to maintain their consumption pattern or even opt for better quality or more expensive products. Thirdly, during the period under analysis, we observe a larger-than-CPI rise in the prices of goods and services characterised by relatively rigid demand. Therefore, the consumption of goods and services in this group was not reduced even in the face of a considerable price growth.

The lack of the product substitution bias also has an important implication from the perspective of monetary and social policy. Firstly, a more accurate index makes anti-inflationary monetary policy more effective and credible. Secondly, one of the points raised by [Boskin et al. \(1996\)](#) was that a positive CPI bias leads to over-indexation of the government programmes. In our paper we show that at least due to the product substitution bias, the indexation in Poland was not excessive. Finally, our outcomes can help the monetary policy authorities to account for the potential CPI bias that would arise from the possible large consumption shifts in the future.

Our research confirmed the provisional hypothesis of a positive plutocratic gap: the democratic index we computed is higher than the plutocratic one. It has to be emphasised that the difference is not treated as the bias in the measurement of inflation. However, the realization of a persistent plutocratic gap (which is present throughout the periods of high and low inflation) may have serious consequences for shaping social policy.

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Appendix

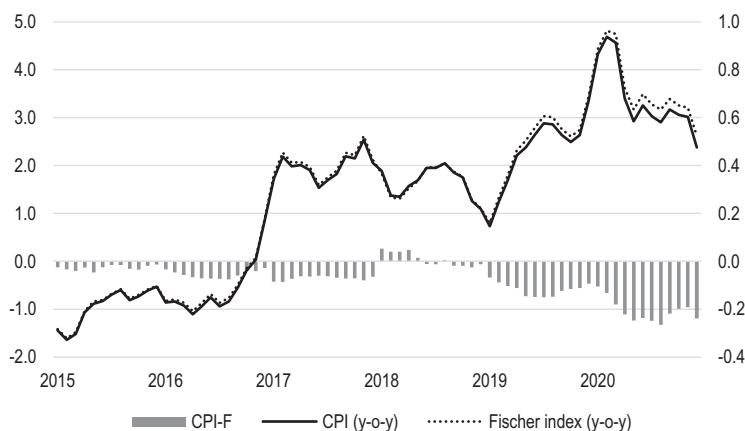


Fig. A1. CPI and Fisher index (%) and the difference (p.p.), 2015–2020

Source: Statistics Poland, own calculations.

Table A1. Price indices relative to the CPI on the 2-digit COICOP level (2010 = 100) and the change in the consumption share between 2019 and 2020

	Price index 2010 = 100, relative to CPI						Change of consumption share in 2020 relative to 2019 (p.p.)
	2015	2016	2017	2018	2019	2020	
Food and non-alcoholic beverages	101.2	102.7	105.0	106.0	108.7	110.1	2.5
Alcoholic beverages, tobacco	108.6	109.9	108.8	108.7	107.6	108.7	0.7
Clothing and footwear	75.4	72.5	67.4	63.9	61.2	57.7	−0.8
Housing, water, electricity, gas and other fuels	108.2	108.1	108.1	108.5	107.7	111.8	0.7
Furnishings, household equipment and routine household maintenance	97.2	97.7	96.1	95.2	93.7	91.5	0.0
Health	103.7	103.5	102.7	103.1	104.0	105.5	0.1
Transport	93.3	89.5	91.1	93.4	91.9	83.9	−1.0
Communication	86.6	86.4	85.3	82.4	80.0	80.2	0.5
Recreation and culture	98.4	97.1	96.5	96.2	96.5	96.0	−0.9
Education	96.7	98.1	97.3	98.0	99.2	101.1	−0.1
Restaurants and hotels	104.3	106.4	106.7	108.0	110.2	112.8	−1.6
Miscellaneous goods and services	98.2	100.3	100.5	98.4	97.5	97.0	−0.2

Source: Statistics Poland, own calculations.

