

Occasional Paper 17

HICP: is there a measurement bias from quality adjustment in Austria and Italy?

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Accurate inflation measurement requires disentangling pure price changes from quality effects. Using Eurostat's approach of defining a plausible corridor for quality adjustment (QA) and microprice data, we investigate the potential for QA-related measurement bias in Austria and Italy. The results show that Austrian HICP indices generally lie well within the corridor, indicating no systematic bias. Italian indices tend to cluster near the lower bound, suggesting possible overadjustment for some products. These differences reflect varying national QA methods and highlight the need for greater harmonization across euro area (EA) price statistics.

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JEL classification

E31, C43, D12

Keywords

Consumer price index, measurement bias, quality adjustment



Assessing measurement bias with microdata

We introduce a microdata-based approach to identify a potential bias in inflation measurement arising from QA. By defining a plausible corridor for quality-adjusted prices, our approach allows for subjectivity in assessing quality changes and accommodates different QA methods.



No systematic bias detected

Our results show no systematic over- or underadjustment in Austria and Italy. Austria's explicit QA methods and Italy's implicit methods generally produce reasonable inflation estimates, though Italy's indices more often approach the lower bound of the corridor.



Harmonization of QA methods needed in the EA

Differences in national approaches reveal a need for stronger harmonization of inflation measurement in the euro area. Aligning QA procedures, sampling and replacement methods would enhance transparency, consistency and trust in official inflation statistics.

Opinions expressed by the authors of studies do not necessarily reflect the official viewpoint of the Oesterreichische Nationalbank or the Eurosystem.

Abstract

Improper quality adjustment has long been identified as a source of potential measurement bias in consumer price indices (CPIs). However, as no benchmark for quality adjustment exists, it has always been difficult to estimate a potential bias. For this paper, we develop a corridor in which quality-adjusted prices are supposed to lie. Its boundaries are defined by the two extreme cases: attributing the entire price change to a change in quality (link-to-show-no-price-change) and assuming unchanged quality when comparing prices (direct price comparison). Analyzing micro price data for a number of non-energy industrial goods in Austria and Italy over the period 2011–2018, we find no evidence of systematic measurement bias induced by the quality adjustment methods implemented in these countries. The actual quality adjustment of prices conducted by Statistik Austria and ISTAT generally lies within the boundaries of the corridor. Nevertheless, inflation rates calculated according to different quality adjustment methods can differ substantially, which calls for further harmonization of quality adjustment practices across euro area countries.

1 Introduction

In price statistics, quality adjustment is one of the major challenges. Prices are always bound to a certain product and its characteristics, which represent the quality of the product. For a price index that compares prices over time, a problem emerges if the quality of the products whose prices are measured changes over time. Therefore, prices should be adjusted to reflect constant product quality.¹ Adjusting prices for quality change is, however, a complex issue, as the value of the quality change is not obvious. One can argue that a price index is biased if quality adjustment is not carried out “correctly”. In its simplest form, a bias would exist if a quality change goes fully unnoticed. Then the difference between an alternative index with quality adjustment and one without would constitute the bias. However, as there is no consensus on how to value different qualities, it seems more intuitive to define a corridor for meaningful quality adjustment results and to classify all values outside this corridor as biased. In this paper, we want to assess the quality adjustment practices in Austria and Italy based on CPI microdata for a number of selected products.² In particular, we investigate whether the quality adjustment conducted by the national statistical institutes (NSIs) happens within such plausible corridors that a possible measurement bias induced by excessive or insufficient quality adjustment can be ruled out.

2 Quality adjustment in theory and practice

2.1 Quality adjustment methodology

In order to account for quality changes when comparing prices of comparable but slightly different products over time, NSIs use several quality adjustment methods. These methods can be classified as implicit

¹Eurostat (2018, p. 92); Von der Lippe (2007, p. 272)

²Data are collected by the Istituto Nazionale di Statistica (ISTAT) and made available to Banca d'Italia under the agreement between ISTAT and Banca d'Italia within the PRISMA framework. The data are confidential and cannot be shared with researchers outside Banca d'Italia. For Austria, the microdata are collected by Statistik Austria and made available to the Oesterreichische Nationalbank (OeNB) for the PRISMA network. They are equally confidential and cannot be shared with researchers outside the OeNB.

and explicit methods of quality adjustment. Implicit ones are based on general assumptions about quality and price changes, while explicit ones take individual product specifications into account.³ The most important implicit methods are direct price comparison⁴ (assuming zero change in quality), link-to-show-no-price-change⁵ (assuming zero price change, as the price difference reflects the quality difference) and bridged overlap (imputing the average price change of the other products in the sample)⁶. While implicit methods are seen as easy to apply in practice and can even be automated, their results may lead to biases.⁷ On the other hand, there are explicit methods for quality adjustment. The most important ones are hedonic quality adjustment (a regression-based approach that explains prices by product characteristics), option pricing (adjusting for features that are now standard but were optional in the past, particularly used for cars) and supported judgmental quality adjustment (“the value of the quality change [...] is calculated by using supplementary information sources”).⁸ The use of explicit methods requires investment in resources, data and human capital, and does not guarantee undisputed results.⁹

Different quality adjustment methods applied to the same data can lead to very different results. This applies especially to implicit methods or when comparing implicit and explicit methods.¹⁰ Keating and Murtagh (2018, p. 6) show the striking example of the application of hedonics and bridged overlap to laptop and desktop computers, which in a period as short as five months led to an 8-percentage-point difference between the adjusted and non-adjusted indices. This raises the question of what “correct” quality adjustment may look like. While it is not possible to define a benchmark for correct quality adjustment, logical boundaries for the value of the quality-adjusted price can be derived, which may facilitate a bias calculation, as we will see in the next chapter.

2.2 Bias from quality adjustment methodology and logical boundaries

When talking about measurement bias in consumer price indices, quality adjustment has always played an important role. Since the report of the Boskin Commission¹¹ on measurement bias in the US CPI, the assessment of quality adjustment bias has been a standard in investigations on CPI measurement bias. It is surprising that, against this background, no standard benchmark for quality adjustment practices has

³For a comprehensive overview, see Eurostat (2019); Eurostat (2018, pp. 105). It should be noted that there is no common nomenclature on quality adjustment methods. For example, the CPI manual (International Monetary Fund, International Labour Organization, Eurostat, United Nations Economic Commission for Europe, Organisation for Economic Co-operation and Development, World Bank, 2020) does not contain the term “bridged overlap”, but “class mean imputation” as a standalone method, while targeted mean imputation and overall mean imputation are seen as variants of the simple overlap method.

⁴Eurostat (2018, p. 106) classifies it as an explicit method; DESTATIS (2009, pp. 29) does not classify it at all, just as in the case of the link-to-show-no-price-change method; Von der Lippe (2007, p. 282) categorizes it as an implicit method, as only prices are taken into account to determine the quality change, not the characteristics of the products. Von der Lippe’s reasoning is followed here.

⁵Synonyms used for this method are “price difference equals quality difference” and “(simple) overlap”. The term “overlap” is used especially when old and new products are included in the basket simultaneously within one time period, while “link-to-show-no price change” can also imply a zero price change between the two periods in which the old product leaves and the new product enters the basket of goods.

⁶Bridged overlap exists in several variants, such as “targeted mean imputation”, “class mean imputation” and “overall mean imputation”. The difference lies in the products used for forming the bridge.

⁷Because of that, the so-called “link-to-show-no-price-change” method, which attaches the full price difference to quality change, is ruled out already by Commission Regulation (EC) No 1749/96.

⁸Eurostat (2018, p. 113).

⁹For example, as regards hedonic quality adjustment: “The experience from some countries has shown that hedonic technique becomes extremely expensive in practice, data collection and the actual modelling are expensive and results are not always feasible. Coefficients are not stable over time, they might be of “wrong” sign, users do not understand this complicated method.” Kinnunen (1998, p. 4); Ahnert and Kenny (2004, p. 26) add that the application of hedonic quality adjustment to the same products, but based on different data sources, sampling techniques and econometrics, may result in price indices that are not fully comparable.

¹⁰See Keating and Murtagh (2018); Goldhammer et al. (2019).

¹¹Boskin et al. (1996).

emerged. The Boskin Commission itself did not clearly distinguish quality adjustment bias and bias from the introduction of new products, therefore applying very different techniques for bias estimation across product groups:¹² assessing consumer surplus by increased variety for food and beverages; back-of-the-envelope calculations for quality differences in housing and new motor cars; comparison to hedonic indices for appliances and electronics; comparison using a matched-model approach for clothing; valuation of an increased service level for motor fuels; and extending the results of particular studies on medical treatments to the whole health sector.

All these techniques have been subject to heavy criticism,¹³ and none of them satisfies the requirements for being an undisputed benchmark for quality adjustment. This is why Lequiller (1997) refused to provide an estimate of quality adjustment bias in his bias study on the French CPI. Because of these experiences, Hoffmann (1998), investigating the quality adjustment bias of the German CPI, followed a slightly different approach by first examining the theoretical properties of the quality adjustment methodologies (already concluding that a bias might be prevalent) and then investigating three product groups (washing machines, fridges, freezers) in detail: his benchmark was hedonic price indices. However, the bias calculations led to very different results depending on the hedonic method used and on the product group.¹⁴ This made Neubauer (1999) conclude that, if no ideal of quality adjustment exists, it is impossible to determine bias from the “real” index of cash values.¹⁵ Therefore, the Schultze report (Schultze and Mackie (2002, p. 113)) stated that “solutions to quality change and new good bias problems must be the fruit at the top of the tree, the kind that requires expensive tools or that may not be reachable at all.”

So, if a benchmark using “correct” quality adjustment is unavailable,¹⁶ the question arises whether there is a corridor in which properly adjusted price indices should lie. At the level of single price quotations, such a corridor has recently been proposed. In its recommendation on the use of bridged overlap, Eurostat¹⁷ elaborates on critical values for plausibility checks of bridged overlap results. These critical values can be applied to any other quality adjustment method, too. The central assumption is that a quality-adjusted price should lie within a corridor defined by two critical values, which reflect the extreme cases of quality adjustment:

- Link-to-show-no-price-change (LNP), where the total nominal price difference is assumed to be fully related to quality change, so the actual price change Δp equals 0.
- Direct price comparison (DPC), where the total nominal price difference is considered equal to the actual price change, so the quality difference Δq equals 0.

For a mathematical determination of the corridor, Eurostat (2021) starts with the following equation, showing the relationship between the price p_n^{t-1} of the outgoing product n in the previous period, the price $p_{n^*}^t$ of the replacement product n^* in the reporting period, the quality adjustment factor $\hat{\alpha}_n$ (to be applied to

¹²Boskin et al. (1996, pp. 27–39).

¹³Especially Moulton and Moses (1997); for a brief discussion of the methods and the criticism, see also Schultze and Mackie (2002).

¹⁴For example, between 1.9 and 2.6 percentage points per year for washing machines and between -0.2 and 0.0 percentage points for freezers, see Hoffmann (1998, p. 105).

¹⁵In German: “Wenn es aber schon an einem halbwegs klaren Idealtypus der Qualitätsänderung fehlt, dann ist es ausgeschlossen, einen Fehlerprozentsatz anzugeben, um den der Index der Qualitätsbereinigung wegen von einem wahren Geldwertindex abweicht.”; Neubauer (1999, p. 30). In the same vein, the Bank of Canada’s estimation of quality adjustment bias considerably declined when using a different method of estimating quality adjustment bias; see Sabourin (2012).

¹⁶If it was available and also technically feasible with given resources, one can assume that it would have been used by statistical offices.

¹⁷Eurostat (2021, Annex 4).

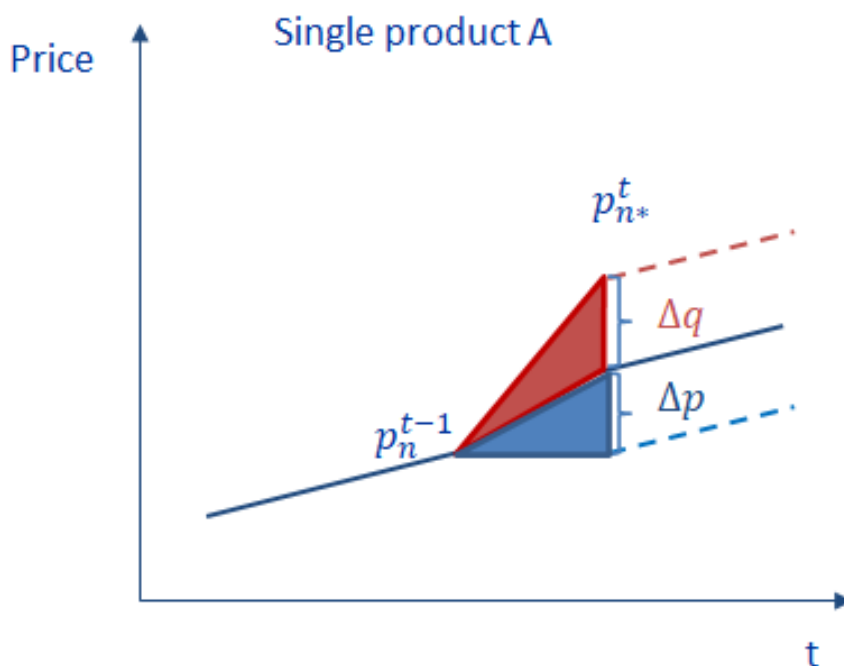
$p_{n^*}^t$) and the “bridge”: the bridge is the actual price change after quality adjustment between the old product and the replacement product for the time period $[t-1, t]$. It is called “bridge” because of the bridged overlap method, for which Eurostat has calculated these boundaries. For our common case – to be applied to all quality adjustment methodologies – we will refer to it as “actual price change factor of product item n at time t ”, r_n^t . Adapting equation (3) in Eurostat (2021, Annex 4), the quality-adjusted (hypothetical) price of product item n in period t can be calculated in the following two ways:

$$p_{n,qa}^t \equiv \frac{p_{n^*}^t}{\hat{\alpha}_n} = p_n^{t-1} \cdot r_n^t \quad (1)$$

In a normal case, we would assume that the quality-adjusted price $p_{n,qa}^t$ lies somewhere between the price of the outgoing product in the previous period and the price of the replacement product in the current period, as shown in chart 1. It is important to mention that this case is one of two regular cases, in which $p_{n^*}^t > p_n^{t-1}$ (in the other case, we would observe $p_{n^*}^t < p_n^{t-1}$).

Chart 1

Regular price–quality decomposition with quality adjustment



Source: Eurostat (2021).

The framework in equation (1) enables us to calculate both the quality change Δq and the “pure” price change Δp as well as the respective values of the extreme cases.

- Δq equals 0 for DPC. For LNP, it follows from equation (1) that:

$$\Delta q = \left(\frac{p_{n^*}^t}{p_n^{t-1}} - 1 \right) \cdot p_n^{t-1} \quad (2)$$

Therefore, the actual price change factor r_n^t equals 1, and the quality adjustment factor is given as $\hat{\alpha}_n = \frac{p_{n^*}^t}{p_n^{t-1}}$.

- Δp equals 0 for LNP. For DPC, it follows from equation (1) that:

$$\Delta p = \left(\frac{p_n^t}{p_n^{t-1}} - 1 \right) \cdot p_n^{t-1} \quad (3)$$

Therefore, the actual price change factor is given as $r_n^t = \frac{p_n^t}{p_n^{t-1}}$, and the quality adjustment factor $\hat{\alpha}_n$ equals 1.

For the extreme cases, Eurostat (2021) calculates the following boundaries for the quality adjustment factor and the real price change factor:

$$\frac{p_n^t}{p_n^{t-1}} \geq \hat{\alpha}_n \geq 1 \quad (4)$$

$$1 \leq r_n^t \leq \frac{p_n^t}{p_n^{t-1}} \quad (5)$$

These boundaries provide a good plausibility check for price index compilation practice. However, we would like to evaluate whether the resulting indices are within logical boundaries, in order to avoid measurement bias. As the logical boundaries on the single-price level are identical to the link-to-show-no-price-change and direct price comparison methods, it seems most reasonable to calculate the hypothetical indices resulting from the application of these methods in all cases of quality adjustment and compare them with the quality-adjusted price indices. So, the following assumptions should hold for price indices at the product group level:

$$if \forall i \in n : p_i^{t-1} < p_i^t : I_n^{DPC,t} \geq I_n^{QA,t} \geq I_n^{LNP,t} \quad (6)$$

$$if \forall i \in n : p_i^{t-1} > p_i^t : I_n^{DPC,t} \leq I_n^{QA,t} \leq I_n^{LNP,t} \quad (7)$$

i is the single product, n the product group. From these assumptions on logical boundaries, the bias calculation can emerge. No bias can only be stated if the quality-adjusted index lies within the logical boundaries. Biases are most commonly expressed in percentage points of the average annual change rate. Hence, if the index lies outside the boundaries, the bias would be the difference between the average annual change rate of the quality-adjusted price index and that of the closest logical boundary. As quality adjustment practices may vary across product groups, it is advisable to conduct this analysis at the product group level rather than for the whole index.

However, equations (6) and (7) already reveal the underlying assumptions and therefore the limitations of this bias calculation: the boundaries of the corridor will not be crossed if the conditions hold in *all* replacement situations. However, there may be cases where the assessed value of the quality difference is greater than the price difference; and it might also happen that, within one product category, replacement prices are sometimes higher and at other times lower than the price of the replaced product. These are caveats to be taken into account when doing such calculations at the index level.

Having set the framework for our calculations on quality adjustment bias, we will present the quality adjustment practices in Austria and Italy, as the results of our research may also shed light on the index differences induced by using different quality adjustment methods.

2.3 Quality adjustment practices in Austria and Italy

2.3.1 Austria

The Austrian data are especially suitable for this analysis because Statistik Austria primarily applies explicit quality adjustment methods, which makes quality adjustment easier to understand and to calculate. Specifically, the Austrian data contain six different flags for quality changes when a product is replaced by a new one with a different quality:

Q0: no (or very small) quality change, the whole price change enters the index calculation. This applies when a new product or service enters the market and the previous one is no longer available, and the new product is a successor with similar or equal quality and is assumed to replace the previous product.

Q1: 25% of the price difference is attributable to the quality difference, hence 75% of the price change is included in the index calculation. This is applied when there are small but relevant quality differences between the old product and the successor.

Q2: 50% of the price difference is due to the quality change and 50% is taken into account for the calculation of the price change. This is applied when there are relevant differences in important features between the predecessor and the new product.

Q3: 75% of the price difference is attributable to the quality change and 25% is assigned to the calculation of the price change. This is applied when there are significant differences in important features between the predecessor and the new product.

Q4: the product or service enters the index without any price change, the quality change fully explains the observed price change. This is often applied when the price is unchanged but, at the same time, the new product has better features.

A special case is the **QZ** flag: it signals a quality difference that can be (exactly) quantified from the characteristics of a product or service and is directly specified in the data. The QZ price is a hypothetical price of the product in the previous period, assuming the same characteristics as the successor product. For instance, in the case of two cars with different equipment where each equipment element has a price, the difference in the equipment can be quantified and then subtracted from or added to the QZ price. The same applies to all products with distinct characteristics that can be priced individually, e.g. PCs or notebooks (graphic card, processor, number of USB ports, etc). For other products where several product characteristics can be observed, such as books or data storage devices (memory cards, USB drives), hedonic methods are used. In this case, the pricing of the characteristics is done in a regression where, e.g. book type and size, number of pages, type of binding (for books) and storage space and type of card or drive (for memory cards/drives) are used as explanatory variables.

Table 1 gives an overview of the occurrence of the different quality adjustment flags across the 12 main groups of the Classification of Individual Consumption by Purpose (COICOP) in 2020. The numbers in the table mean that, e.g. in COICOP group 03 “Clothing and footwear”, Q0 (no quality change) is applied to

2.0% of all price observations in this group, Q1–Q3 have been assigned to 0.8% of all price observations, etc. According to the last column of the table, Q0 has been applied to about 0.4% of all price observations in the whole basket of goods and services.

Table 1

Occurrence of quality adjustment flags per COICOP 2-digit group in 2020 in Austria in % of all observations

COICOP-2 groups	01	02	03	04	05	06	07	08	09	10	11	12	Total HICP
Q0	0.0	0.0	2.0	0.0	2.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.4
Q1–Q3	0.1	0.1	0.8	0.1	1.0	0.1	0.1	0.0	0.3	0.7	0.1	0.1	0.3
Q4	0.0	0.0	0.4	0.1	0.6	0.0	0.1	2.8	0.2	0.1	0.3	0.1	0.2
QZ	0.4	0.4	1.2	0.2	1.0	0.1	0.6	1.0	0.8	0.2	0.1	0.8	0.6

Note: COICOP 2-digit groups: 01 Food and non-alcoholic beverages; 02 Alcoholic beverages, tobacco and narcotics; 03 Clothing and footwear; 04 Housing, water, electricity, gas and other fuels; 05 Furnishings, household equipment and routine household maintenance; 06 Health; 07 Transport; 08 Communication; 09 Recreation and culture; 10 Education; 11 Restaurants and hotels; 12 Miscellaneous goods and services.

Source: Statistik Austria.

2.3.2 Italy

The Italian National Statistical Institute (ISTAT) has adopted a case-by-case approach for quality adjustment, as required by Commission Regulation (EC) No 1334/2007. Specifically, the methods adopted to manage quality adjustment issues are:

1. Direct comparison:

- (a) for clothing and footwear, when the product offers in two consecutive months are seen as comparable on the basis of criteria defined by ISTAT. In the month of replacement, the elementary price is flagged, the reason for the replacement is recorded and a direct comparison is carried out directly by automatic procedures;
- (b) in some cases involving processed or fresh food (for which prices are collected monthly) when, for a list of products defined by ISTAT, the change of the product offer is due exclusively to a change of brand, and therefore the product offers in two consecutive months are considered comparable. In the month of replacement, the elementary price is flagged, the reason for the replacement is recorded and the data collector has to register the price of the product offer available in the previous month as the previous month's price of the new product offer;
- (c) for products for which a best seller approach is adopted, such as electronic games, DVD movies;
- (d) for fresh food and fish, for which prices are collected twice a month, in the month of replacement, the elementary price is flagged and the reason for the replacement is recorded.

2. Bridged overlap: Bridged overlap implicitly imputes a price for the new product offer in the previous period and thereby values the quality difference as the price gap between the old and new product offers in the previous period. Two variants are possible: in the first variant, the price change of the incoming product compared to the preceding period is considered equal to the price change recorded for the reference group that has not registered any substitutions of that particular product. In the second variant, the price change of the incoming products compared to the preceding period is considered equal to the price change recorded for the reference group that has registered replacements

of that particular product and for which the direct comparison approach or explicit methods have been adopted.

- (a) in some cases involving clothing and footwear, when the product offers in two consecutive months are considered incomparable on the basis of criteria defined by ISTAT. In the month of the replacement, the elementary price is flagged, the reason for the replacement is recorded and an automatic procedure estimates the previous month's price of the new product offer in order to build the bridge between the two consecutive months.
3. Link-to-show-no price-change ("overlap"): This method estimates the value of the quality difference between the outgoing and incoming references as equivalent to the price difference between the two references at a time when both references were available. In this case, the replacement of a reference always involves the collection of additional data in order to reconstruct the temporal price dynamics of the new reference.
- (a) for the other products, whose prices are collected monthly at the territorial level (except clothing and footwear, products for which prices are collected centrally, fresh and processed food for which direct comparison is carried out). In the month of the replacement, if the data collector has recorded the previous month's price of the replacing product offer (or the seller is able to provide this information), this information is used and the elementary price is flagged. If the data collector has not recorded the previous month's price of the replacing product offer (and the seller is not able to provide this information), an automatic estimate is used.

The Italian microprice database contains a flag with four options for changes: change of collected unit, change of brand, change of reference quantity and change of variety. The change of brand and variety could be considered as quality changes.

3 Methodology for assessing a possible measurement bias related to quality adjustment

In order to assess whether the quality adjustment procedures used by Statistik Austria and ISTAT, as documented by these flags, may lead to a bias in inflation measurement, we re-calculate inflation for three different quality adjustment assumptions for a number of selected products. In doing so, we follow the critical boundaries outlined in section 2.2. One boundary index follows, for all replacement situations, the assumption underlying LNP that the new quality-adjusted price is equal to the old price. The other boundary index uses the assumption of the DPC method that the quality difference is either negligible or 0, therefore directly comparing the old and new prices in a replacement situation. The third index we calculate uses actual quality adjustment (QA) conducted by Statistik Austria and ISTAT, as documented in the index production systems by the flags mentioned above. Under reasonable assumptions, the new quality-adjusted price should fall somewhere in between the old and new prices, and thus the price index actually calculated by Statistik Austria and ISTAT should lie between the indices derived from the two extreme assumptions, which represent the upper and lower bounds for reasonable quality adjustment. Put differently, if the actual price index systematically and permanently exceeds the range spanned by the upper and lower bounds, we would conclude that quality adjustment is so strong that a measurement bias in inflation of that partic-

ular item cannot be ruled out.

It is important to stress that a bias can only be assumed for cases of systematic and permanent deviation beyond the range spanned by the DPC and LNP indices. In single cases, there can be justified exemptions from that rule, such as seminal technological progress. Therefore, we have focused our judgment on the annual average change rate of all three indices for periods of six years (Austria) and seven years (Italy), respectively, taking into account a large number of replacement cases. This should help us form a robust judgment about the possibility of a bias.

Overall, our exercise can be seen as a plausibility check of the actual quality adjustment conducted by the statistical institutes rather than a check for correctness, as quality adjustment, especially in its explicit form (Austrian data), is and will always be a subjective decision of the statistician at work.

4 Data

4.1 Austria

The Austrian dataset used to calculate the quality-adjusted indices consists of monthly observations from January 1996 to December 2017 for over 1,000 products and services. However, we limit our analysis to the period after the introduction of chain-linking in the Austrian HICP in 2011, since the update of the goods basket at 5-year intervals prior to this date is usually associated with extensive redefinitions of product descriptions which would create a break in our indices. In addition, we include only selected products from the non-energy industrial goods (NEIG) component, as quality adjustment plays a minor role for the other components of the HICP, i.e. food, energy and services.¹⁸ The products within the NEIG component were chosen on the basis of (1) a high incidence of quality adjustments and (2) significant weight or representativeness of the product within subgroups of products, e.g. one furniture item, one IT product, one clothing item, etc.

Based on these considerations, we chose the following 12 products to be included in our analysis: bed-room furniture, sofa set, dishwasher, electrical razor, toothbrush, washing machine, lawn mower, sink, laundry detergent, notebook/tablet, PC and men's jeans.¹⁹ These products together account for about 3% of the Austrian HICP.

4.2 Italy

We use monthly micro consumer price data provided by ISTAT, covering the period from January 2011 to December 2018. In particular, we use prices collected locally once a month by municipal statistical offices in over 70 provincial capitals. Hence, our sample does not include prices collected centrally (e.g. cars) and those collected locally more than once a month (e.g. some unprocessed fresh food items). The dataset comprises around 3.5 million observations per year, classified into 267 8-digit COICOP categories, which are in turn grouped into 69 4-digit COICOP categories.

Based on the same considerations as for Austria (a high incidence of quality adjustments and significant

¹⁸See also table 1. Most products we include in our analysis are in COICOP group 05 (Furnishings, household equipment and routine household maintenance).

¹⁹Product names correspond to the official category definitions according to the COICOP classification further customized by the NSIs; plural forms are used in the text for readability and grammatical consistency.

weight or representativeness of the product within subgroups of products), we chose the following ten products for inclusion in our analysis: men’s pants, women’s pullover, washing/dryer machine and dishwasher, bedroom furniture, laundry detergent, fridges and freezers, appliances for heating and air conditioning, TV, small electronic appliances (razor/toothbrush), jewellery and clocks. These products together account for about 2% of the Italian consumer price index.²⁰

5 Results

5.1 Austria

In chart 2 we show the evolution of the price indices recalculated on the basis of the above-mentioned flags: the index reflecting the actual quality adjustment conducted by Statistik Austria (blue line) together with the indices under the assumption of direct price comparison (DPC, turquoise line) and the assumption of link-to-show-no-price-change (LNP, beige line). All indices start at 100 in January 2011.

As can be seen from chart 2, for most of the displayed products, the quality-adjusted price index according to information from Statistik Austria remains within the upper and lower bounds as defined above. For bedroom furniture and PCs, for example, the quality-adjusted price index is very close to the DPC index. This means that the adjustment of prices due to quality changes is relatively small, such that there is little difference from the case where there is no quality adjustment. In contrast, for sofa sets and laundry detergents, the major part of the price changes is assessed to be due to quality changes, resulting in a similar trajectory between the quality-adjusted price index and the LNP index. For most remaining products in chart 2, the quality-adjusted price index is somewhere in the middle between the upper and lower bounds. Exceptions are sinks and electrical razors, for which the quality-adjusted index is slightly below the lower bound in the period between 2014 and 2017 (sinks) and in 2011 (razors). This can only happen when prices increase while quality decreases, or when both prices and quality decrease, with quality decreasing proportionally more than prices. These are quite unusual situations that should not occur in the data too often. Both examples are also remarkable in that the DPC and LNP indices intersect at one point in time (razors in 2011, sinks in 2015), which may point to a fundamental change in the market and probably drives the quality-adjusted index outside the corridor for some time. Finally, for the only clothing item in our sample, men’s jeans, all three price indices follow a clear seasonal pattern and align closely with each other. This implies that quality adjustment apparently only plays a minor role for clothing.

From this evidence, we conclude that, with only few exceptions, quality adjustment of the Austrian data – at least for the products in our sample – is undertaken within reasonable bounds and, thus, there is no indication of systematic measurement bias induced by quality adjustment. Of course, this conclusion is only based on a small number of products, but these products appear to be quite representative of the whole non-energy industrial goods sector.

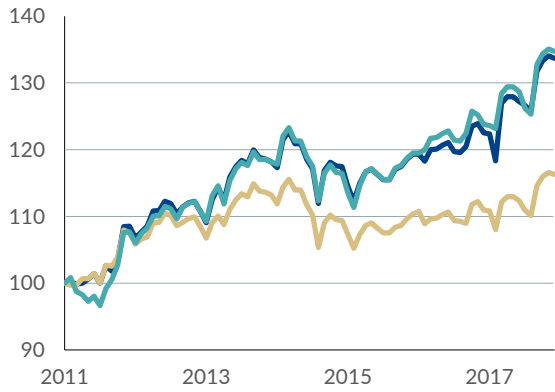
How do the differences in the three indices for the QA, DPC and LNP cases translate into differences in inflation rates? Chart 3 shows the annual inflation rates corresponding to the indices shown in chart 2.

²⁰As for Austria, we include only selected products from the non-energy industrial goods (NEIG) component, as quality adjustment plays a minor role for the other components of the HICP, i.e. food, energy and services. Notice that bedroom furniture has been available in the PRISMA database since 2012; data on TVs, washing/dryer machines and dishwashers, and fridges and freezers are available until 2017.

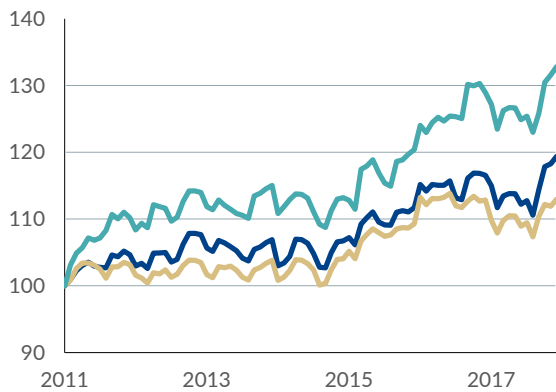
Chart 2

Austria: price indices for different quality adjustment assumptions

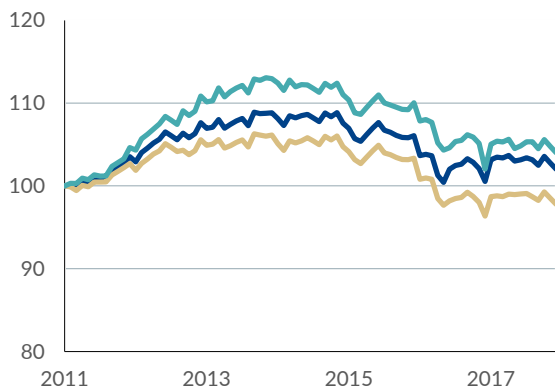
Bedroom furniture



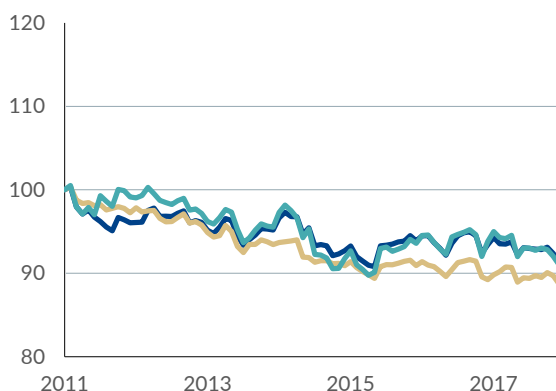
Sofa set



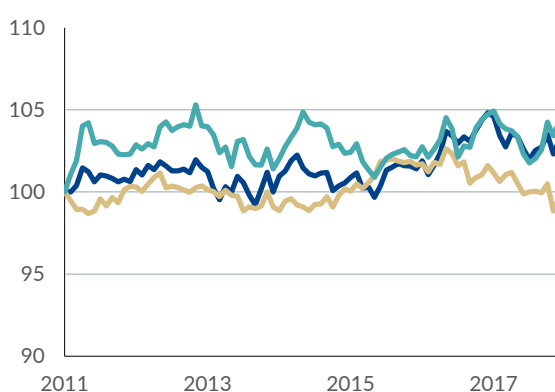
Toothbrush



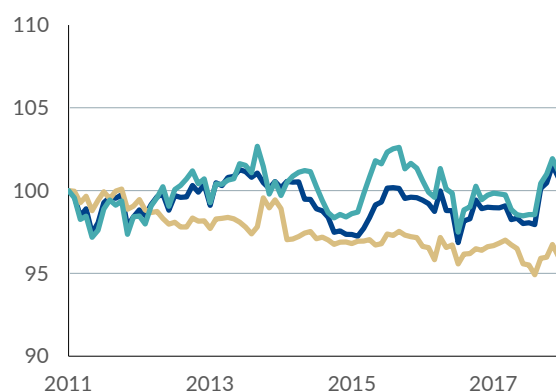
Electrical razor



Dishwasher



Washing machine



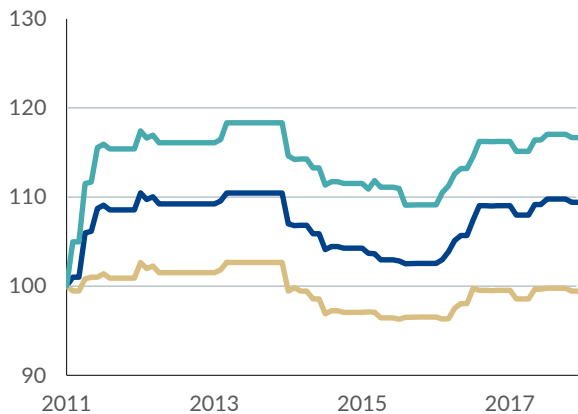
— Quality-adjusted index — Index LNP — Index DPC

Note: LNP: link-to-show-no-price-change, DPC: direct price comparison, index Q1 2011 = 100.
 Last observation: Dec. 2017.
 Source: Statistik Austria, authors' calculations.

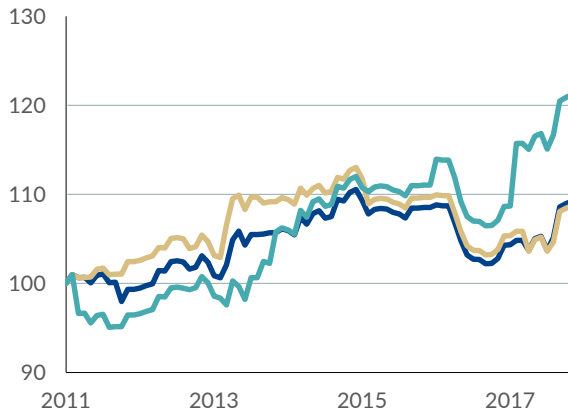
Chart 2

Austria: price indices for different quality adjustment assumptions (continued)

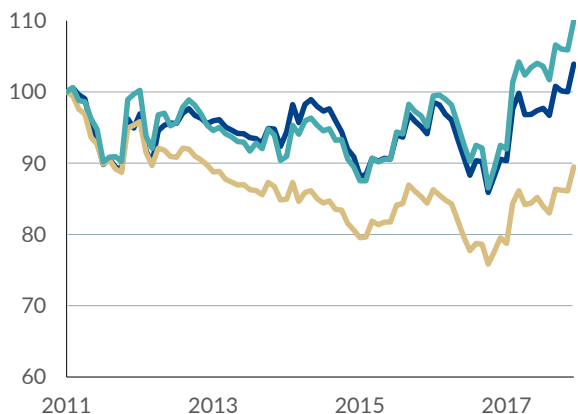
Lawn mower



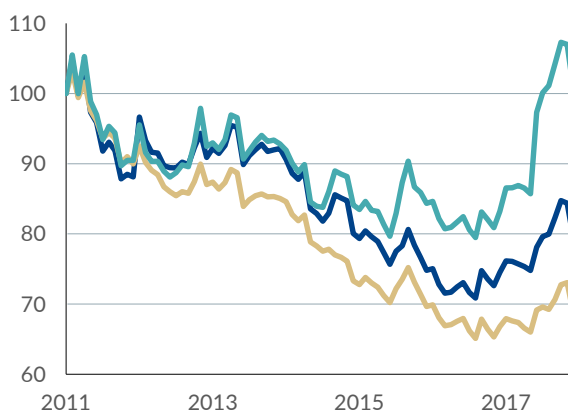
Sink



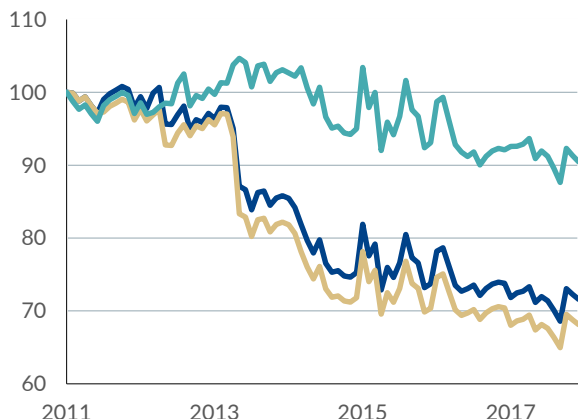
PC



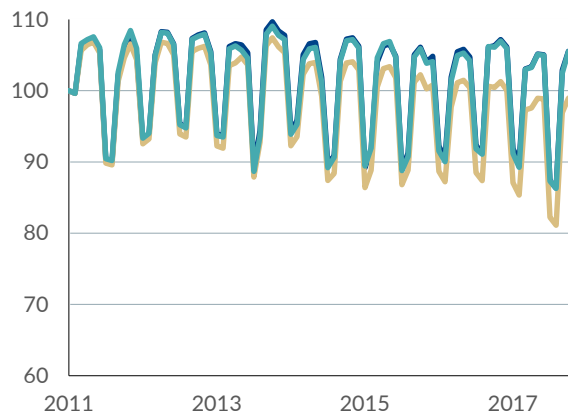
Notebook/tablet



Laundry detergent



Men's jeans



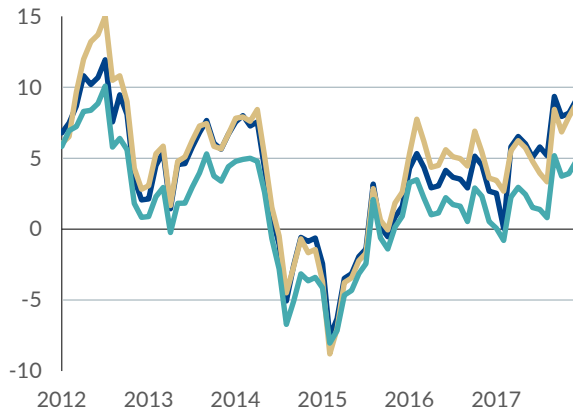
— Quality-adjusted index — Index LNP — Index DPC

Note: LNP: link-to-show-no-price-change, DPC: direct price comparison, index Q1 2011 = 100.
 Last observation: Dec. 2017.
 Source: Statistik Austria, authors' calculations.

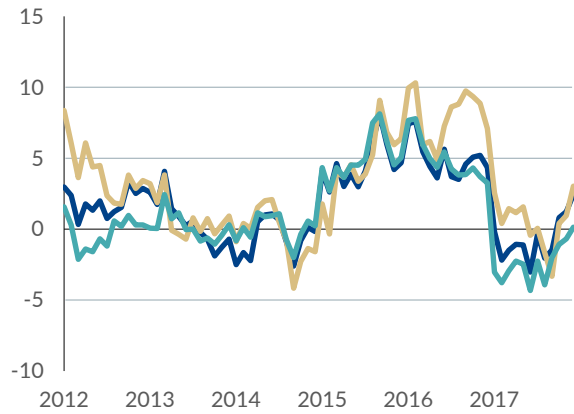
Chart 3

Austria: inflation for different quality adjustment assumptions

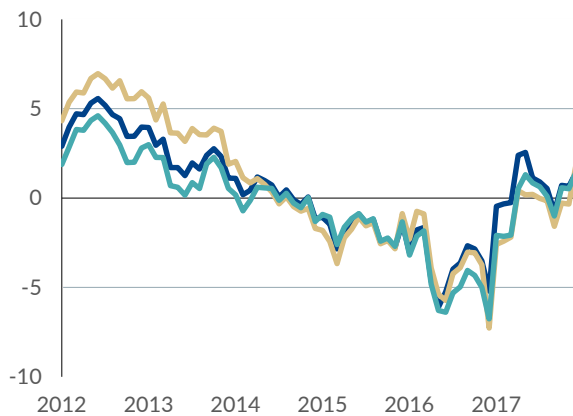
Bedroom furniture



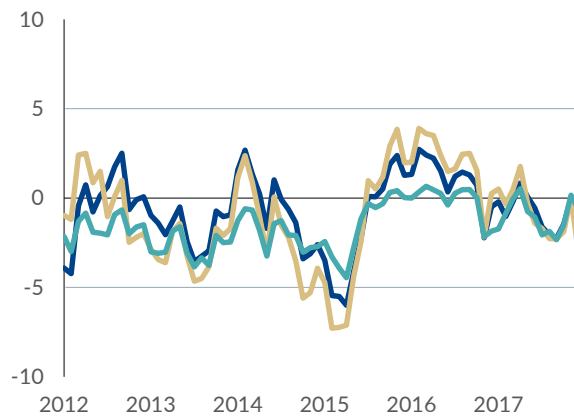
Sofa set



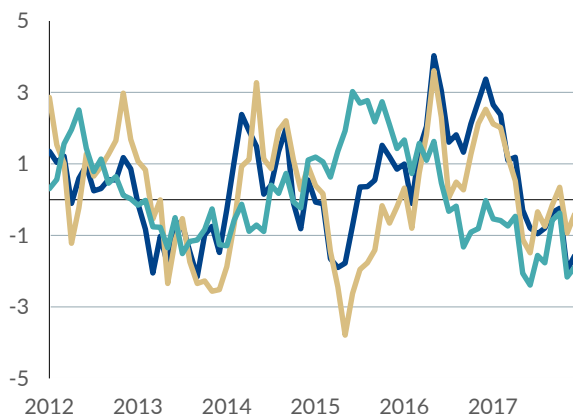
Toothbrush



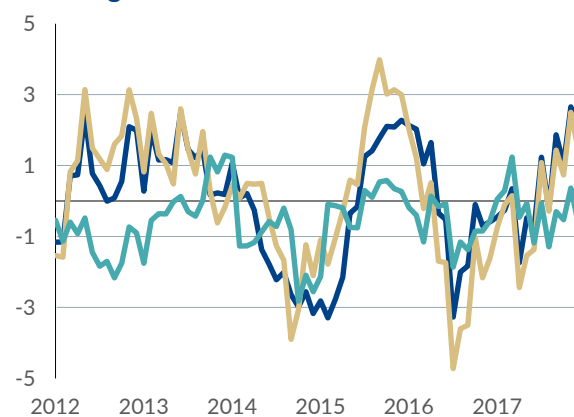
Electrical razor



Dishwasher



Washing machine



— Quality-adjusted inflation (y-o-y) — Inflation DPC (y-o-y) — Inflation LNP (y-o-y)

Note: LNP: link-to-show-no-price-change, DPC: direct price comparison, inflation rates in percent.

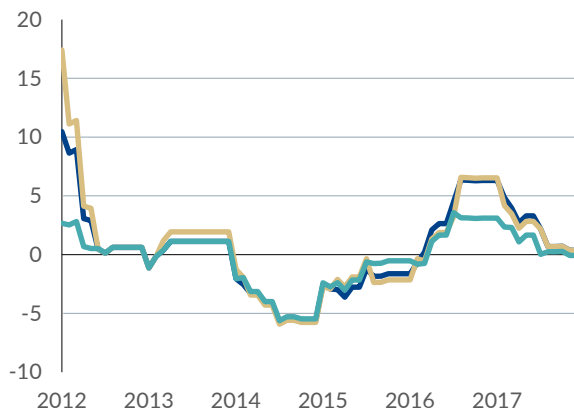
Last observation: Dec. 2017.

Source: Statistik Austria, authors' calculations.

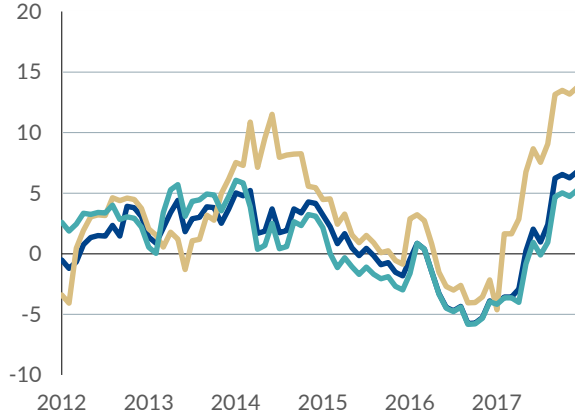
Chart 3

Austria: inflation for different quality adjustment assumptions (continued)

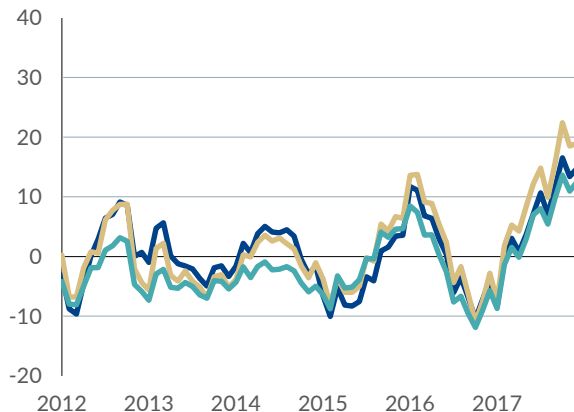
Lawn mower



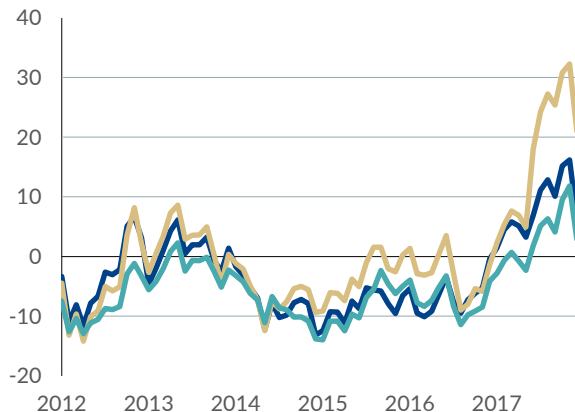
Sink



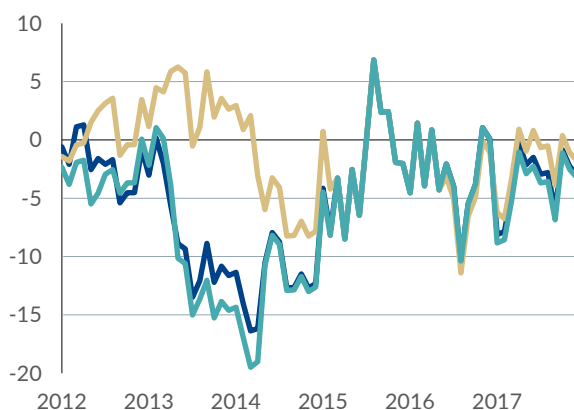
PC



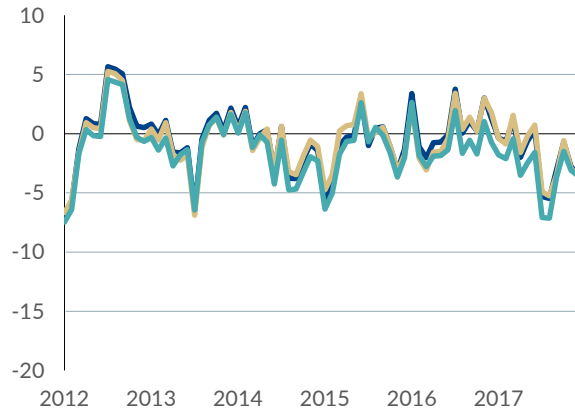
Notebook/tablet



Laundry detergent



Men's jeans



— Quality-adjusted inflation (y-o-y) — Inflation DPC (y-o-y) — Inflation LNP (y-o-y)

Note: LNP: link-to-show-no-price-change, DPC: direct price comparison, inflation rates in percent.
 Last observation: Dec. 2017.
 Source: Statistik Austria, authors' calculations.

From eyeballing we can see that, for most products and time periods, the inflation rate based on the actual quality adjustment of Statistik Austria lies between the inflation rates implied by the upper and lower bounds, DPC and LNP, respectively. There are only very few and temporary exceptions. Moreover, for most products and time periods, the inflation rates under the three assumptions of quality adjustment appear to be quite close to each other. However, looking at the axis scale of the charts, we realize that inflation at the item level is quite volatile. For this reason, it is difficult to say just by looking at the charts whether different ways of quality adjustment have a sizeable impact on the resulting inflation rates. To address this, we report average annual inflation for the period 2011–2017 for the three types of quality adjustment and each product in table 2.

Table 2

Austria: average inflation for different quality adjustment assumptions in % (2011–2017)

Products	DPC	QA	LNP
Bedroom furniture	4.3	3.8	1.7
Sofa set	2.9	1.8	1.2
Dishwasher	0.4	0.2	0.2
Electrical razor	-0.9	-0.7	-1.5
Toothbrush	0.6	0.3	-0.3
Washing machine	0.2	0.1	-0.6
Lawn mower	0.7	0.4	-0.2
Sink	3.2	1.0	0.8
Laundry detergent	-1.2	-5.3	-6.0
Notebook/tablet	-0.1	-3.1	-5.3
PC	1.3	0.6	-1.7
Men's jeans	-0.6	-0.5	-1.4

Note: DPC denotes direct price comparison, QA the quality adjustment according to information from Statistik Austria and LNP link-to-show-no-price-change.

Source: Authors' calculations.

Table 2 reveals that, for most products, inflation rates based on the actual quality adjustment using information from Statistik Austria lie between the DPC and LNP inflation rates. Exceptions are electrical razors and men's jeans, with negligible deviations. For most products, the difference between the three quality adjustment methods is quite significant. The largest differences are observed for notebooks/tablets and laundry detergents, followed by PCs, bedroom furniture and sinks. Taking the example of notebooks/tablets, compared to the quality adjustment conducted by Statistik Austria, inflation in the period 2011–2017 would have been about 3 percentage points higher if there was no quality adjustment of prices and by 2.2 percentage points lower if all price changes were completely explained by quality changes. On average across all products considered, quality-adjusted inflation turns out to be exactly in the middle between the two extreme cases represented by DPC and LNP.

5.2 Italy

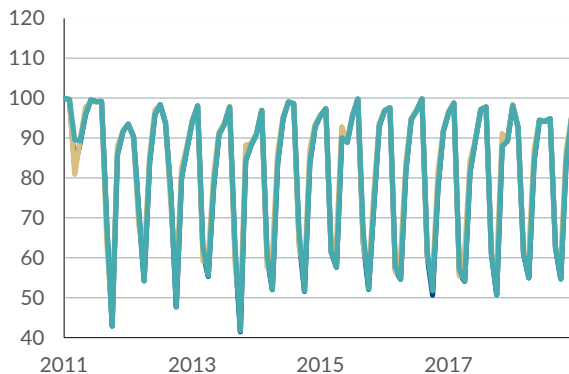
We report the results for price indices for three cases: the actual CPI index computed by ISTAT using quality adjustment (blue line) together with the indices under the assumption of direct price comparison (DPC, turquoise line) and under the assumption of link-to-show-no-price-change (LNP, beige line).

As can be seen from chart 4, the differences between the upper and lower bounds are much smaller in Italy than in Austria. The official index is always close to the lower bound, which means that price changes

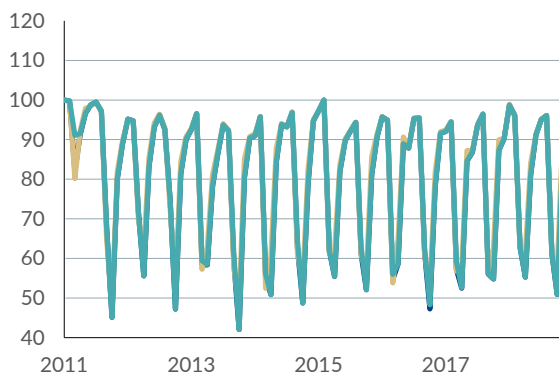
Chart 4

Italy: price indices for different quality adjustment assumptions
Chart 3: Prices indices for different quality adjustment assumptions

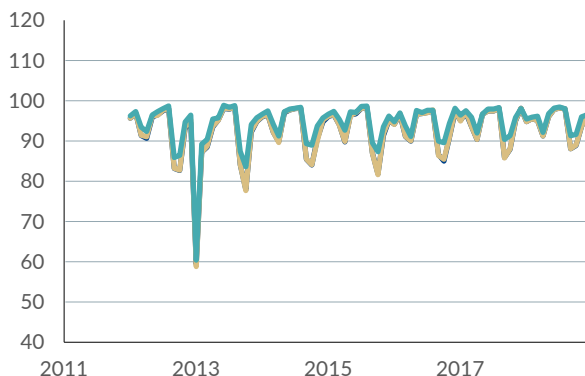
Men's pants



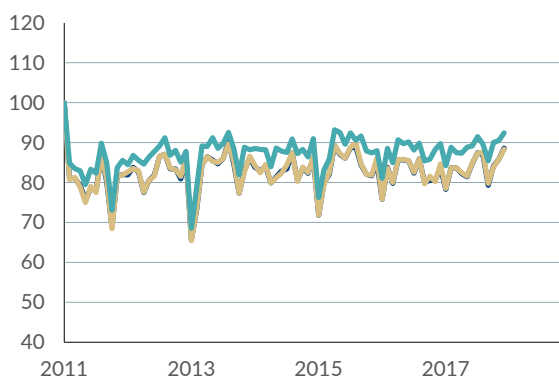
Women's pullover



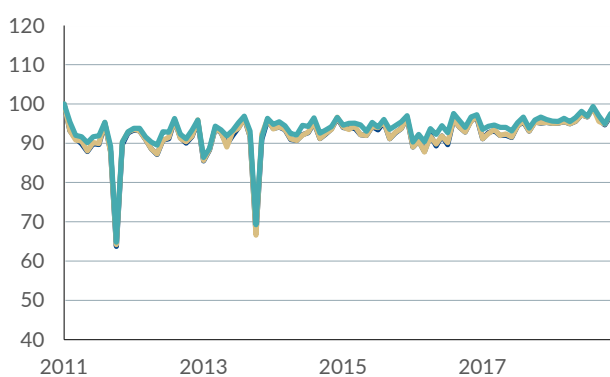
Bedroom furniture



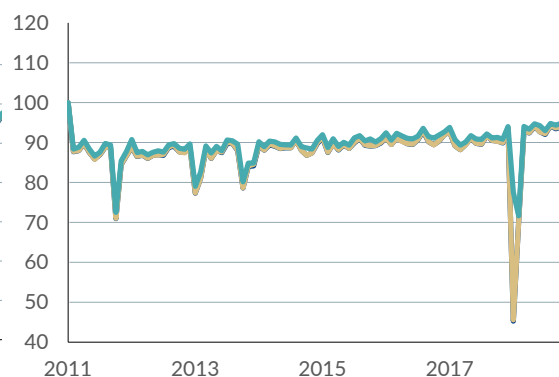
Washing/dryer machine and dishwasher



Appliances for heating and air conditioning



Laundry detergent



— Quality-adjusted index — Index LNP — Index DPC

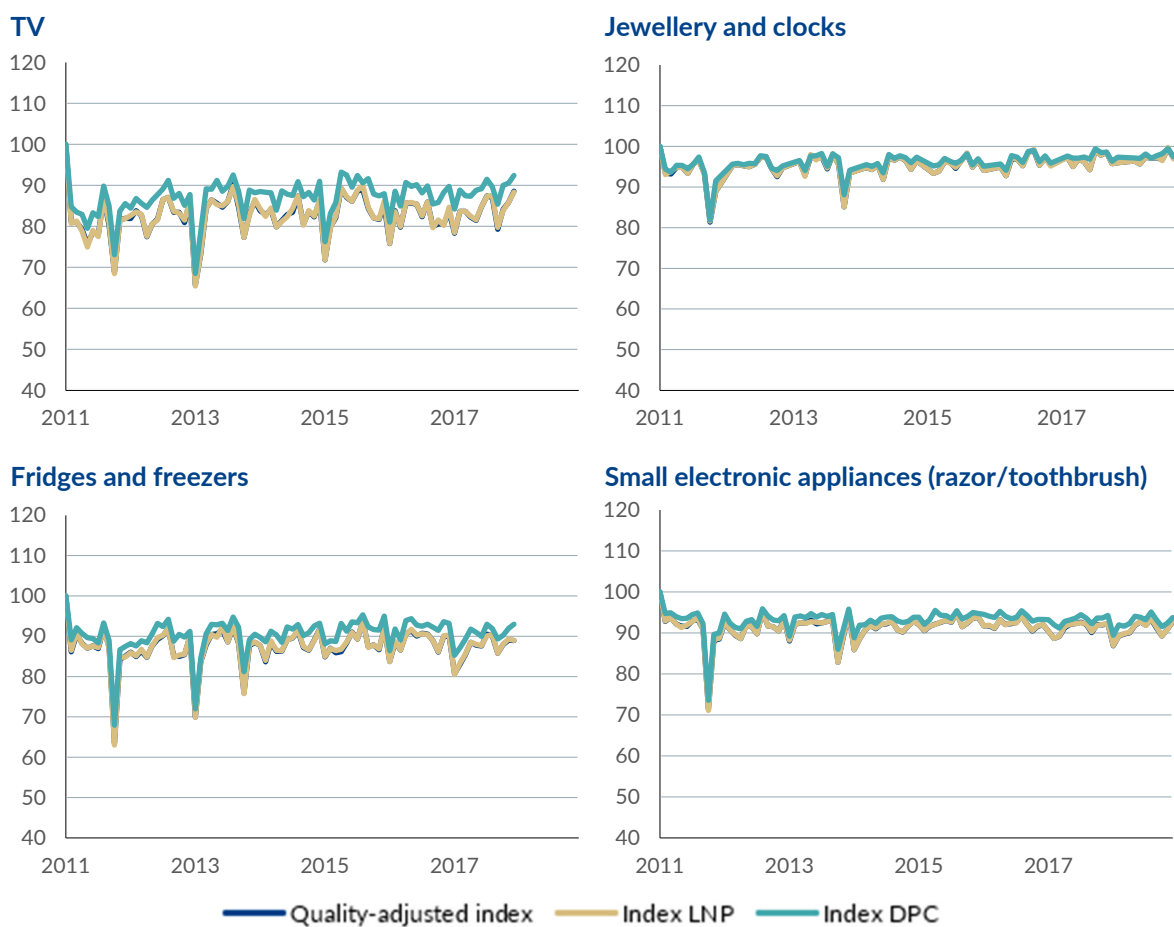
Note: LNP: link-to-show-no-price-change, DPC: direct price comparison, index Q1 2011 = 100.

Last observation: Dec. 2018 (washing/dryer machine and dishwasher: Dec. 2017).

Source: ISTAT, authors' calculations.

Chart 4

Italy: price indices for different quality adjustment assumptions (continued)

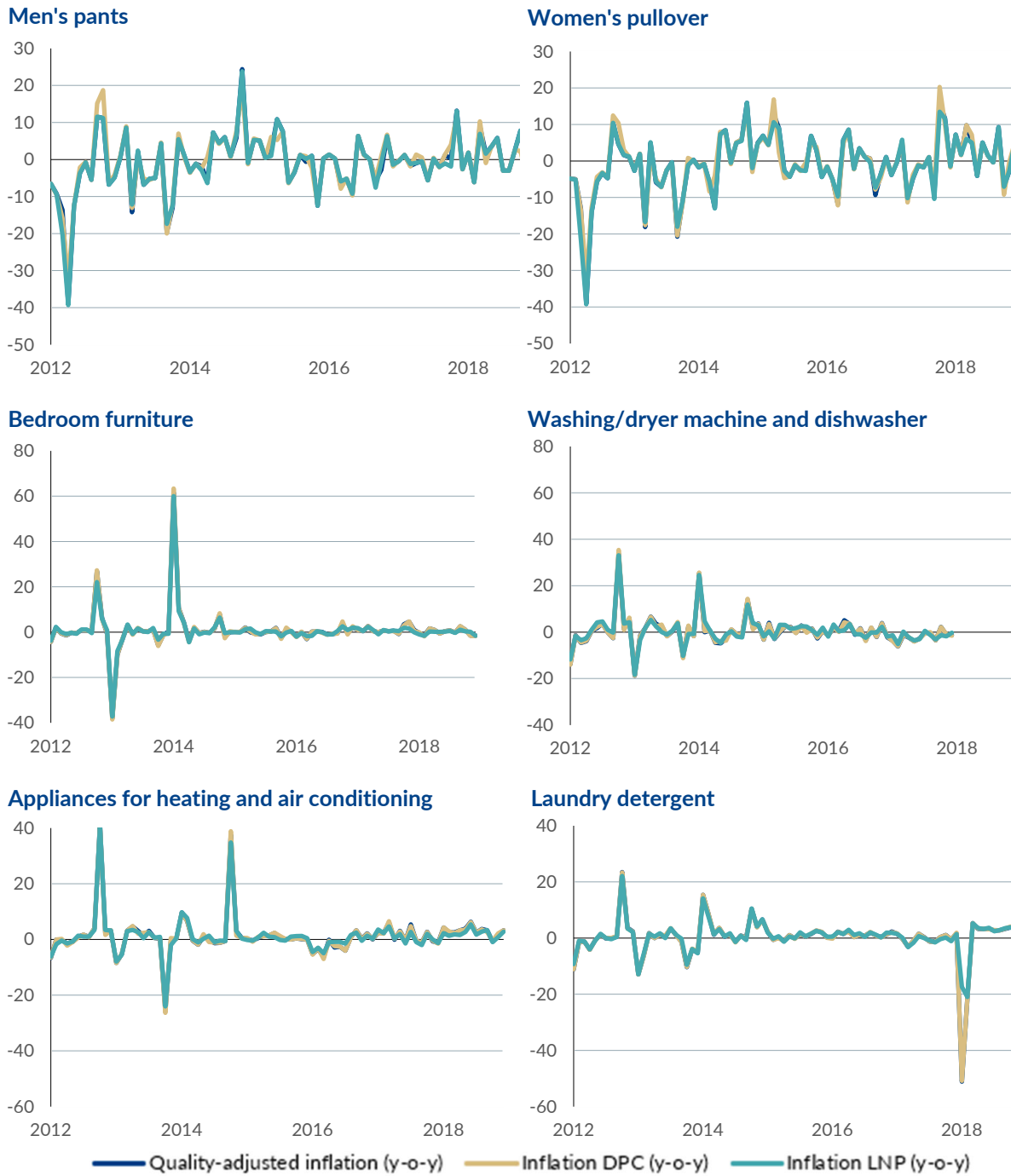


Note: LNP: link-to-show-no-price-change, DPC: direct price comparison, index Q1 2011 = 100.

Last observation: Dec. 2018 (TV and fridges and freezers: Dec. 2017).

Source: ISTAT, authors' calculations.

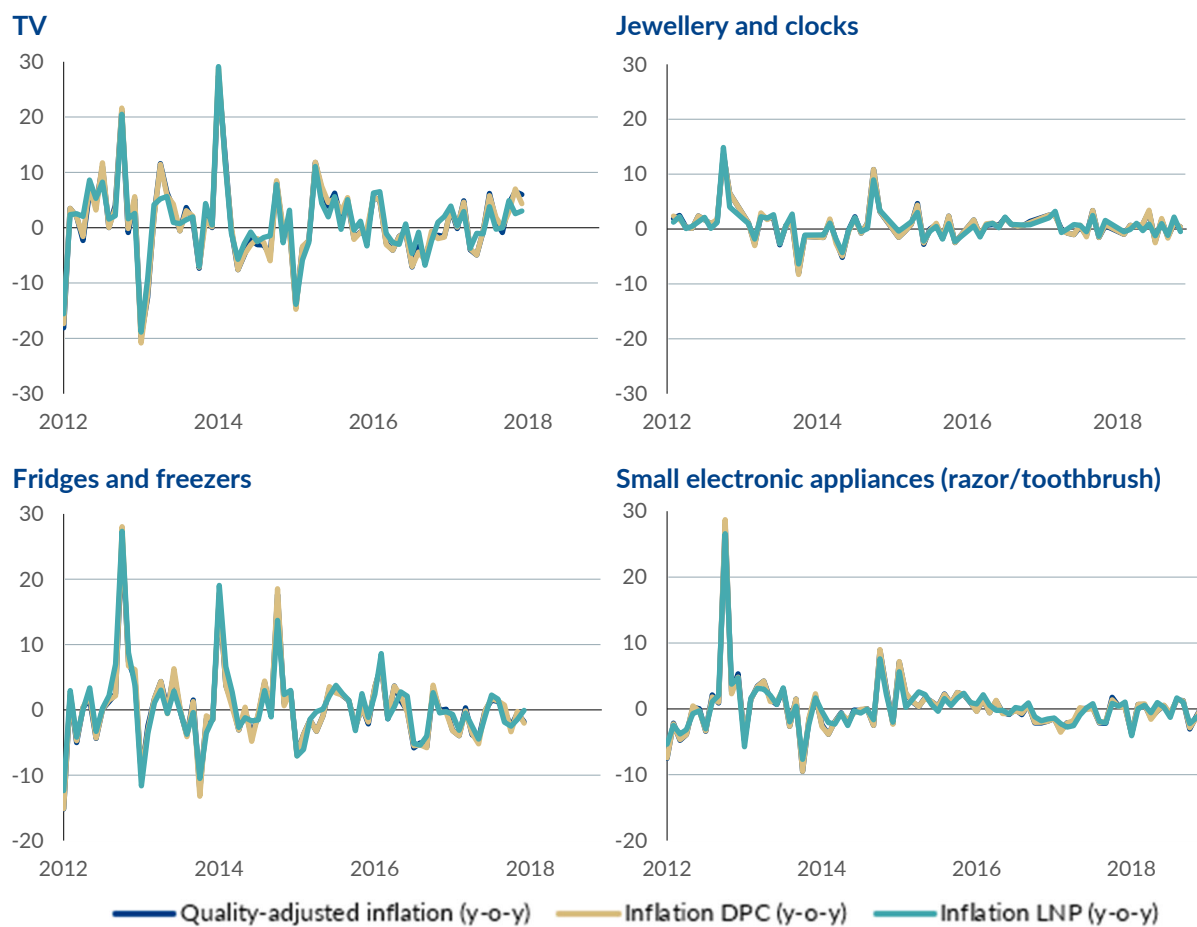
Chart 5
Italy: inflation for different quality adjustment assumptions



Note: LNP: link-to-show-no-price-change, DPC: direct price comparison, inflation rates in percent.
 Last observation: Dec. 2018 (washing/dryer machine and dishwasher: Dec. 2017).
 Source: ISTAT, authors' calculations.

Chart 5

Italy: inflation for different quality adjustment assumptions (continued)



Note: LNP: link-to-show-no-price-change, DPC: direct price comparison, inflation rates in percent.
 Last observation: Dec. 2018 (TV and fridges and freezers: Dec. 2017).
 Source: ISTAT, authors' calculations.

in replacement situations are mainly attributed to changes in quality: it means that we can interpret the quality adjustment that was actually carried out as representing the lower bound. This points to a different philosophy for the strategy of sampling, replacement and quality adjustment as a whole, using a rather narrow definition of products to avoid complex quality adjustment procedures in replacement situations.

From this evidence, we conclude that quality adjustment of the Italian data – at least for the products in our sample – is undertaken within reasonable bounds and, thus, there is no indication of systematic measurement bias induced by quality adjustment. Our conclusion is based on a small number of products that are representative, in our view, of the non-energy industrial goods sector. The same holds when we look at inflation rates as shown in chart 5.

Finally, we present the average annual inflation for the period 2011–2018 for the three cases of quality adjustment and each product in table 3. In the sample period considered, it seems that for four out of ten products, the quality-adjusted CPI index is outside the corridor; in two cases, it is below the lower bound and in two cases above. However, in all of these cases, the gap between the corridor and a possible bias is small; with the exception of bedroom furniture, the bias would be within rounding margins.

Table 3

Italy: average inflation for different quality adjustment assumptions in % (2011–2018)

Products	DPC	QA	LNP
Men's pants	-0.02	-0.02	0.07
Women's pullover	-0.22	-0.22	-0.09
Washing/dryer machine and dishwasher	-0.00	-0.01	-0.01
Bedroom furniture	0.16	0.23	0.20
Laundry detergent	0.38	-0.07	-0.07
Fridges and freezers	-0.93	-1.34	-1.32
Appliances for heating and air conditioning	0.61	0.71	0.69
TV	-0.38	-0.63	-0.64
Small electronic appliances (razor/toothbrush)	-0.06	-0.08	-0.09
Jewellery and clocks	0.31	0.26	0.27

Note: DPC denotes direct price comparison, QA the quality adjustment according to information from ISTAT and LNP link-to-show-no-price-change.

Source: Authors' calculations.

6 Discussion

The results shown in the previous section lead us to some remarkable conclusions. First, depending on national practices, the corridor for meaningful quality-adjusted prices may be of substantially different size: Austria shows rather large corridors, Italy rather small ones. As pointed out before, we can conclude that both countries follow different strategies for the complex of sampling, replacement and quality adjustment: Austria seems to use wide product descriptions and compensate for rather arbitrary replacements by explicit quality adjustment; Italy seems to use narrow product descriptions or narrowly defined strata, which limits the corridor and also implies rather similar quality adjustment results, independent of the method.

Second, neither the method we have used nor the results point to the existence of substantial quality adjustment biases in the CPI of either country. Where the quality-adjusted index lies outside the corridor,

the difference is always rather small and points to a downward bias.

Third, the results also show that, even within the corridor, the use of certain quality adjustment procedures may drive the inflation rate in a certain direction. One example is laundry detergents in Austria, where, despite a 4.8-percentage-point difference in the average change rates of the DPC and LNP indices, the QA index is only 0.7 percentage points above the lower bound. Systematically applied, a quality adjustment policy could be used that leads to substantially different inflation rates despite using justified QA methods that lie inside the corridor. This calls for additional harmonization efforts for sampling, replacement and quality adjustment methods within the euro area.

Fourth, the results also show the limits of our method. From the perspective of propositional logic, we cannot conclude that a bias exists merely because the quality-adjusted index lies outside the corridor. We can only conclude that, if the index is inside the corridor, it has no bias. The example of one product whose price requires a quality adjustment that exceeds the corridor for well-justified reasons – due to technological progress – underlines this logical consideration.

Another limitation is that the method seems to require rather stable market conditions, i.e. a fixed order between DPC and LNP indices. A situation as observed for sinks in Austria, where the DPC index surpassed the LNP series after several periods, makes the interpretation of the results of the quality-adjusted index problematic, at least for the periods around the change. In addition, as quality adjustment may exceed the corridor in single cases, the time span over which the method should be applied is rather long, in order to make a general judgment as to whether the corridor is maintained. The use of indices and long-term averages is an outcome of this limitation.

7 Conclusions

The aim of this paper is to show a new approach for determining a potential measurement bias in the CPI caused by improper quality adjustment. We try to assess – based on microdata from a number of selected non-energy industrial goods – whether the quality adjustment practices in Austria and Italy happen within reasonable boundaries or whether they lead to a possible bias in the measurement of item-specific inflation.

The approach we have taken is driven by microdata, as the results of quality adjustment can only be observed at that level. Determining a meaningful corridor for quality-adjusted indices also addresses the impossibility of defining quality in an undisputed way and the necessity of subjective judgments by the statistician conducting quality adjustment.

Our results for Austria indicate that, for most of the products and time periods, the quality adjustment based on information from Statistik Austria leads to inflation rates that are lower than those obtained without any quality adjustment and higher than those that would result from applying a quality adjustment strong enough to completely offset the price changes. For some of the products considered, such as bedroom furniture, toothbrushes and washing machines, the quality adjustment is rather small, such that the resulting inflation rates resemble those obtained when no quality adjustment is applied. For other products, however, such as sofa sets, sinks and laundry detergents, the quality adjustment is strong enough to almost compensate for the entire price change. Only for PCs (in the period from 2013 to 2014) and for

electrical razors (in 2016 and 2017), we find evidence of excessive quality adjustment that overcompensates price changes and should therefore be interpreted with caution. Whether a small quality adjustment is preferable or more correct than an extensive quality adjustment is difficult to assess a priori. Especially in its explicit form, which is widely used in Austria, quality adjustment always involves a subjective decision by the statistician, meaning that any approach to quality adjustment can be justified. However, our results show no evidence of systematically overstated quality adjustment across many products in Austria that would lead to a bias in the measurement of inflation.

For Italy, where ISTAT mainly uses implicit methods of quality adjustment, the results are reasonable and show no evidence of major quality adjustment biases in price indices and inflation rates. However, with the exception of two cases, the official index for the chosen products is close to the lower bound, meaning that the Italian CPI may be near the minimum of what could be considered a reasonable range of quality-adjusted indices.

The differences between the explicit and implicit methods used by Statistik Austria and ISTAT eventually call for more harmonization of quality adjustment, sampling and replacements among euro area countries in the future. Our study itself may be a trigger for more microdata-driven studies on quality adjustment, as quality adjustment procedures can be assessed only at this level.

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Publisher and editor	Oesterreichische Nationalbank Otto-Wagner-Platz 3, 1090 Vienna, Austria PO Box 61, 1011 Vienna, Austria www.oenb.at oenb.info@oenb.at Phone (+43-1) 40420-6666
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