Problems of Inflation Measurement in Germany

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Summary

In this study, the accuracy of inflation figures in Germany, as measured by the Consumer Price Index, will be examined on both a theoretical and empirical basis. In similar studies, which have so far been carried out in particular for the United States, four major sources of bias have been identified:

- bias resulting from the use of a "wrong" index formula (product substitution bias),
- bias due to inappropriate quality adjustment of prices (quality change bias),
- bias resulting from delayed consideration of new products (new product bias), and
- bias due to insufficient consideration of changes in the retail structure (outlet substitution bias).

These potential errors of measurement taken together, the evidence for Germany is that the true rate of inflation is overstated by the officially recorded increase in the Consumer Price Index. In this respect, the outcome is identical to that of studies for other countries. According to the results in this paper, however, the overall bias in Germany seems to be smaller than e.g. in the United States and might, in normal circumstances, be of the order of 3/4 percentage point per year. The by far largest contribution to this overall bias stems from difficulties in measuring prices in the event of quality changes.

The paper is organized as follows: Chapter 1 gives an overview of the typical problems of inflation measurement and potential sources of bias. In Chapter 2 the German Consumer Price Index is described in detail. Chapter 3 provides an assessment of the substitution bias using a range of experimental price indices. The first part of chapter 4 is devoted to a detailed theoretical analysis of the instructions for adjusting prices in the face of quality changes, as issued by the Federal Statistical Office. According to that analysis, the bias should be small when quality improvements are close to the product-specific price increase; if the absolute magnitude of price changes is well above the concomitant quality change, the bias will be larger. In the case of quality improvements, it will be positive, and vice versa. These findings are supported by selected empirical case studies. The overall quality bias is then extrapolated from a set of stylised facts. In chapter 5, a critical analysis of the way the Federal Statistical Office handles the emergence of new goods is followed by a case study illustrating the implications of disregarding new goods in the Consumer Price Index. Finally, in chapter 6, the changes in the retail structure in Germany and their implications for inflation measurement are analysed.

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I. The Measurement Bias in the Rate of Inflation*

> „Just as subatomic particles are the basic building blocks of physics, so the prices and quantities of goods, services, and assets bought and sold are the fundamental building blocks of the economy, the informational foundation upon which virtually everything we know about the economy rests. If prices or their rate of change (inflation) are not measured accurately, there will be cracks in the foundation and we will become prisoners of faulty statistics."
> Boskin (1997)

The problem of measuring inflation accurately is an old one in economics. As early as the beginning of the 18th century papers were being written on the issue of price indices.[1] Following the disastrous periods of inflation and deflation, the debate then had its first heyday in the first half of the 20th century; the studies at that time focused mainly on theoretical aspects of the accurate measurement of the rate of price increases.[2]

Interest in the problems of measuring inflation waned in the ensuing period, particularly in Europe, but the subject has recently been receiving greater attention again. One reason for this is undoubtedly the fact that central banks have now become more oriented towards price stability than they were before, with recorded rates of inflation in quite a number of countries being not far from zero. This means that the problem of measuring inflation accu-

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* This is an abridged and revised version of Discussion paper 1/98 "Probleme der Inflationsmessung in Deutschland" of the Economic Research Group of the Deutsche Bundesbank. The omissions concern mainly comments on methodology which are of greater relevance to the discussion in Germany than to that of the international public. However, especially those passages of the paper which contain a detailed description of the German Consumer Price Index have been included with few alterations.

Without the generous support from the experts of the Federal Statistical Office, particularly from Günther Elbel and Johann Szenzenstein, a critical review of the German Consumer Price Index would have been doomed to failure from the outset. This paper also benefited from discussions that took place in workshops at the Deutsche Bundesbank and at the ZEW and at symposia held jointly by the Deutsche Bundesbank with Jürgen von Hagen and with the Economic Studies Division of the Österreichische Nationalbank. I am particularly grateful to my colleagues Robert Fecht, Hermann Hansen, Hans-Albert Leifer, Wolfgang Rippin, Georg Wels and Thomas Westermann as well as to the Head of the Deutsche Bundesbank's Economic Research Group, Heinz Herrmann, and Stefan Homburg (University of Hannover), who read the draft in its various stages and generously offered stimulating comments and criticism. It goes without saying that any remaining errors (and incorrect assessments) are my own.

1 See Diewert (1988).

2 In German-speaking countries, these were primarily Haberler (1927) and Flaskämper (1928); for an overview, see Frisch (1936).

rately is becoming even more important for monetary policy makers. Another reason is that a large number of US studies have shown in detail that traditional methods of measuring inflation can lead to a considerable overstatement of the upward trend in prices. Consequently, only qualified use can be made of the rates of inflation published by the statistical offices for drawing economic policy conclusions.

It is only recently that greater attention has again been paid to problems of measuring inflation in Germany. The - sometimes heated - debates of the fifties and sixties on the interpretation of published rates inflation and on the methodology of price statistics, to which members of the Federal Statistical Office made a major contribution,[1] were followed in the seventies by some theoretical studies on index concepts, which did not meet with any response in terms of practical work,[2] and by a few studies on concrete problems of measuring price changes.[3] By the eighties the interest in problems of measuring inflation had again died down almost completely in Germany.

The situation in the United States is entirely different. There academics and the public alike have been monitoring price statistics critically for decades. Not only experts from the BUREAU OF LABOR STATISTICS, which has traditionally been responsible for preparing the CONSUMER PRICE INDEX (CPI) in the United States, but also universities and research institutions, in particular, and economists from the Federal Reserve System, too, are involved in the debate. In the United States, stimulating contributions to the debate on price indices came from large-scale studies that had been commissioned by public institutions. At the beginning of the sixties, the STIGLER-COMMISSION[4] critically reviewed US price statistics as a whole and made a series of recommendations, some of which were subsequently implemented. Above all, however, the Commission popularised new areas of research and, at the same time, new methods which were later to prove extremely fruitful not only for economic science, but also for price statistics in practice. Among these was primarily what is known as the hedonic method for taking account of quality changes in price measurement; the opportunities offered by this method were set out by Griliches in an accompanying Staff Report, taking the US automobile market as an example.[5] Of funda-

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1 See, for example, Deneffe (1950), Deneffe/Keller (1956), Deneffe/Hiller (1958), Fürst (1960) and Guckes (1964).

2 See, in particular, Eichhorn/Voeller (1976) and the contributions in Eichhorn (1978) and Lange (1979).

3 See Reich/Sonntag/Holub (1977) and the contributions in Fürst (1976).

4 Price Statistics Review Committee of the National Bureau of Economic Research (1961).

5 See Griliches (1961).

mental importance for trends in price statistics as a whole was the recommendation to establish permanent research bodies within the relevant authorities, which were to undertake studies in the field of price statistics relatively independently while remaining in close contact with day-to-day work. This recommendation was subsequently implemented by the establishment of the DIVISION OF PRICE AND INDEX NUMBER RESEARCH at the Bureau of Labor Statistics.

Despite all these efforts, there still appears to be a large bias in the recorded rate of inflation in the United States. At all events, a commission of experts[1] (known as the BOSKIN-COMMISSION), which was established by the Financial Committee of the Senate, came to the conclusion at the end of 1996 that the US Consumer Price Index exaggerates inflation by 1.1 percentage point per annum.

Why is it so difficult to measure aggregate price change accurately in practice? If all prices moved parallel over time, there would hardly be a bias in inflation measurement. It would be entirely sufficient to monitor the price of one good or service activity, and all the necessary information would be available. In a dynamic economy, however, new goods are continually entering the market, new marketing methods become established, and relative prices change owing to differing trends in productivity.

Partly for very pragmatic reasons, but also partly on considerations of principle, statisticians are not, say, attempting to incorporate all these changes immediately in the rate of inflation. One of the main reasons for this is that the public and politicians demand price indices that are up to date; for example, one does not want to wait until December to find out what the rate of inflation was in March. Therefore, in many countries statisticians adopt a different method - at least as for inflation measurement over shorter periods: price changes are collected in selected shops for a fixed basket of narrowly specified goods. The price index then measures the "uncontaminated" price increase for this particular bundle of goods. In some cases, this method is even specified as the normative ideal, since it prevents inflation measurement from being "contaminated" by new products or by a change in the pattern of consumption.

However, in price statistical practice, it is, firstly, virtually impossible to adhere to such a strict principle over a longer period; secondly, it would not make sense. If, for example, old product variants, or sometimes even entire categories of products are taken out of the mar-

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1 Advisory Commission to Study the Consumer Price Index (1996).

ket and replaced by new products, there would very soon be a dramatic fall in the number of goods for which prices can still be collected. Hence, if the price index figure is not to lose its significance as a representative figure, a break with this method is inevitable. The statistical offices therefore adhere to a fixed basket of goods only for a limited period and continually incorporate price series for products that are similar in quality and link them with those for old products. In principle, it is thus recognised that inflation measurement should be geared to CURRENT CONSUMPTION PATTERNS. From the point of view of economic history, it would undoubtedly be interesting to know what the price would be today of an average basket of goods of 1900, but such a bundle of goods would certainly be unsuitable for assessing price trends in 1998.

Measured against the general demand for an PRICE INDEX THAT IS "UP TO DATE" AND RELEVANT TO ECONOMIC POLICY, FOUR MAJOR BIASES in the recorded rate of inflation can be identified (following the example of previous studies undertaken for other countries), which may be summarised under the same number of headings and matching questions:[1]

- The PRODUCT SUBSTITUTION BIAS: Are price changes for individual goods aggregated correctly to obtain the overall rate of inflation? According to the Laspeyres principle, inflation is measured on the basis of a fixed basket of goods; if, for example, consumption patterns shift towards less expensive goods owing to changes in relative prices, the weighting is no longer up to date and the rate of inflation is overstated.
- The QUALITY CHANGE BIAS: Are prices measured accurately when the quality of products changes? Only a small number of products remain unaltered in the market for a longer period of time. In the case of manufactured products, model changes usually occur once a year, in the case of clothing even twice a year. Thus the statistical offices have to link price series for old and for new models; any changes in quality should be extracted. In practice this proves to be very difficult, and most studies on this problem suggest that in many cases prices are not correctly adjusted for quality improvements.
- The NEW PRODUCT BIAS: Do the goods that have not been considered in inflation measurement exhibit a price trend that is different from the price index? Every year a large number of new products come on to the market; these are generally included in the price index only with a considerable time-lag, namely when price statisticians switch to a new basket of goods. Viewed in isolation, this would not cause too many problems if

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1 The distinctions are not strictly clear-cut; despite certain overlaps, however, they have proved their worth in practice.

it were not for the fact that, in many cases, successful new products exhibit a downward price trend in the first few years after they have been launched on to the market, which results in the price increase of a basket of goods without new products being overstated.

- The OUTLET SUBSTITUTION BIAS: Are the prices of the goods recorded correctly? Prices are typically collected in the same outlets in order to isolate "uncontaminated" price changes. By doing so, however, the structural changes in the distribution sector, which offer customers less expensive shopping facilities, are left unconsidered in inflation measurement.

Of the large number of STUDIES ON MEASUREMENT BIASES IN PRICE STATISTICS[1] the above-mentioned Boskin report[2], in particular, met with great public interest. At the same time, a number of further studies were carried out in the United States which also concluded that the US Consumer Price Index overstates inflation (Table 1). Comparable studies on United Kingdom and Canada arrived at similar results.

All these estimates are largely based on the findings on individual problems of price statistics in the United States. Owing to the large number of such detailed studies, however, an extrapolation of the results obtained for the United States appears to be legitimate in many cases. Nevertheless, representatives of the Bureau of Labor Statistics and other critics have indicated that, in their view, many assessments of the Boskin-Commission are not very well founded and that alternative back-of-the-envelope calculations, which are at least as plausible, produce more favourable results for the US price statistics.[3]

All in all, the studies show that the measurement bias caused by changes in quality and new goods are likely to be the most important ones. In the United States fairly high figures are also obtained for the product substitution bias; these figures, however, contain distortions caused by a problematic method for aggregating prices for individual products, which has led to an additional measurement bias owing to other special features in the way the rate of inflation in calculated in the United States.[4]

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1 For an overview, see Triplett (1975) and Wynne/Sigalla (1996), or Kortelainen (1997).

2 Advisory Commission to Study the Consumer Price Index (1996).

3 These are, for example, Moulton (1996), Abraham (1997), Bureau of Labor Statistics (1997), Moulton/Moses (1997). However, see also Boskin et al. (1998).

4 This bias has now largely been eliminated.

Table 1: Estimates of the bias in inflation measurement

Deviation of the recorded annual rate of inflation from the true rate of inflation (in percentage points)	Product substitution bias	New product / quality change bias	Outlet substitution bias	Total bias
Congressional Budget Office (1994) USA	0.3 to 0.6	-0.1 to 0.2	(0 to 0.2) [1]	0.2-0.8
Lebow et al. (1994) USA	0.4 to 0.6	0 to 0.8	0 to 0.1	0.4 to 1.5
Advisory Commission to Study the Consumer Price Index (1996) USA	0.4	0.6	0.1	1.1 (Plausible range 0.8 to 1.6)
Shapiro/Wilcox (1996) [2] USA	(0.2) + (0.25)	(0.2) + (0.25)	(0.1)	1.0 (with a probability of 80 % in an interval between 0.6 and 1.5)
Diewert (1995)	0.2 + 0.5	0.35-0.6	0.25 - 0.4	1.3 to 1.7
Diewert (1997) USA	0.2 + 0.35 to 0.5	0.1 to 0.5	0.1 to 0.5	0.75 to 1.7
Diewert (1998) USA	0.5	1.0	0,4	1.9
Fortin (1990) Canada	< 0.2	0.3 to 0.8 [3]		0.5 to 1.0
Crawford (1993) Canada	0.1 to 0.2	< 0.3	0.1	0.5
Crawford (1998) Canada; upper bound	0.1	0.5	0.1	0.7
Crawford (1998) Canada; mean	0.1	0.3	≅ 0.07	≅ 0.5
Cunningham (1996) UK	0.05 to 0.1	0.2 to 0.45	0.1 to 0.25	0.35 to 0.8
Baxter (1997) [4] UK	0.06 to 0.07	?	< USA	< USA
Lequiller (1997) [4] France	0.05 to 0.1	< USA	0.05 to 0.15	< USA
Diewert (1997) „typical official consumer price index"	0.2	> 0.35	0.25	> 0.8

[1] Not included in total.
[2] Mean of given distributions.
[3] Only new product bias.
[4] No data given on new product / quality change bias.

In Germany, it is only the DEUTSCHE BUNDESBANK which - some time ago - ventured an assessment of the bias in inflation measurement. In a report for the FEDERAL FINANCE COURT prepared in 1965, the Bundesbank's experts reached the following conclusion:

> "In general, it should not be considered a reduction in the value of money if the cost-of-living index for the "medium" consumer group rises by, say, 1 per cent per annum; and an annual increase of between 1 and 2 per cent in the index can be regarded as indicating a deterioration in the value of money only with certain reservations."[1]

This study attempts to find a new answer for Germany to the old question of the accuracy of inflation measurement. Its content is confined to the CONSUMER PRICE INDEX; the region covered is WESTERN GERMANY,[2] and the period considered is that from 1980 to 1996.

The aim of this study could not be to apply the methods of the Boskin-Commission in its entirety to Germany. While Boskin and his colleagues were able to draw on extensive preliminary work undertaken by statistical offices and academic economists, this is scarcely the case for Germany. Since the review of the German Consumer Price Index should not be restricted to applying the results from the United States to Germany in a more or less speculative manner, both the price measurement and the methods of aggregation will be analysed. This will be supplemented by selected case studies, which, however, can serve merely as examples. The results of these case studies then will be generalised. Inevitably, these extrapolations include a subjective element. In this respect, the conclusions of this study are subject to the reservation that further studies need to be undertaken.

Neither was it the purpose of this study to demonstrate that the Federal Statistical Office made any errors in calculating the Consumer Price Index. Rather, its aim is to gain an idea of the magnitude of a possibly lasting deviation of the Consumer Price Index from an ideal index. Mostly for technical reasons, the methods applied have usually not been suitable for everyday price measurement and for compiling monthly price index figures; furthermore, the results are partly based on subjective estimates which are out of place in official statistics.

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1 Deutsche Bundesbank (1968).

2 Inflation measurement for eastern Germany has met with problems that are virtually impossible to be solved, owing to the rapid structural change which occurred particularly in the first few years after German unification.

Extrapolation of individual examples is limited especially in those areas which are governed by special laws. In this respect, three major areas within the Consumer Price Index can be identified, which must be left for future studies to analyse in detail. First, there is the AREA OF HOUSING. In Germany - similarly to the United States, but unlike the practice in many other European countries - notional payments are assumed in the case of owner-occupied dwellings. In addition, the collection of data on rents is restricted to apartments with three to four rooms; there are thus no price representatives for single-family houses and one-room and two-room apartments, which may have displayed a stronger upward price trends in the past few years. Furthermore, houses and apartments undergo an ageing process. The respective increases to rents, however, are not shown in the German price statistics, so that quality-adjusted price increases for dwellings understate the true rate of price increase.

Owing to the paramount importance of the statutory health insurance funds in Germany, the HEALTH SECTOR is largely disregarded in inflation measurement at the consumer level. The statutory health insurance funds, in which the majority of the population in Germany is insured, adhere to the principle of benefits in kind; the insurance contributions are measured as a percentage of wages and diminish disposable income. Neither the contributions nor the expenditure of the statutory health insurance funds are included in the Consumer Price Index. For that reason, health sector services are given a very low weight in it: for example, in the basket of goods based on the consumption patterns of 1991, approximately 4 % of the expenditure was accounted for by pharmaceuticals, medical services and private health insurance (whereas the contribution rate to statutory health insurance is an average 13 1/2 % of eligible income). Owing to the above-average price increases in medical services, the inflation measured on the basis of the Consumer Price Index in Germany possibly understates price increases from a macroeconomic point of view. On the other hand, studies carried out in the United States show that, in many cases, even sharp rises in the cost of medical services and pharmaceuticals are accompanied by a correspondingly higher quality,[1] making a hasty assessment scarcely possible.

In the field of medical services, various problems of price measurement are particularly acute; they are not unknown in other sectors either, however. Especially in respect to

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[1] Shapiro/Wilcox (1996), for example, demonstrate this using experimental price indices for operative surgery on cataracts; Cutler/McClellan/Newhouse/Remler (1996) do so for the treatment of myocardial infarctions.

SERVICES, questions as to "What is quantity - what is price?" arise.[1] While manufactured products can be defined, at least in principle, by their physical characteristics, this approach fails especially in the case of knowledge-intensive services.[2] For a long time, it was assumed -not without some justification - that improvements in quality are concentrated on the manufactured goods sector; however, the expansion of the tertiary sector, particularly in the field of information-related services, has given rise to problems that price statisticians can solve only with great difficulty, if traditional methods are applied.[3]

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1 See Fürst (1971). For special problems of price measurement in the services sector, see Kroch (1991) and Armknecht/Ginsberg (1992).

2 See Greenspan (1997).

3 See also Griliches (1994).

II. The German Consumer Price Index

A CONSUMER PRICE INDEX for western Germany has been published only since 1969.[1] Up to that time, only TYPIFYING PRICE INDICES FOR INDIVIDUAL GROUPS OF HOUSEHOLDS had existed. Nowadays, special price indices are calculated for three groups of households:

- a consumer price index for four-person households of civil servants or salary earners with higher income,
- a consumer price index for four-person households of salary or wage earners with middle income, and
- a consumer price index for two-person households of pensioners or recipients of social assistance with low income.

These indices differ from the overall index only in respect of household-specific weighting; the prices are obtained from the general consumer price statistics, as is the case with the overall Consumer Price Index.

The various consumer price indices are calculated as modified LASPEYRES INDICES with a weighting pattern that does not change over several years and which is derived from households' average consumption expenditure in the base year concerned. Although the index is rebased every five years as a rule, the weights are usually four years old when the index is introduced (Table 2). Hence, the age of a basket of goods is normally nine years when switching to a new base year takes place. The average age of the implicit quantity structure used for current inflation measurement is thus around 6 1/2 years. Therefore, it is quite probable that a bias arises because of the substitution problem (and owing to the time-lag with which new goods are included). When a new basket of goods is presented, results that have been calculated retroactively back to the new base year are usually published; in order to obtain long series, these figures are linked to the old index.

Thus, in the long series a basket of goods typically covers half a decade with an average age of no more than 2 1/2 years. Accordingly, the substitution bias and the bias caused by

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[1] For the German Consumer Price Index, see Fürst/Deneffe (1952), Danner (1975), Neubauer (1981) and Deutsche Bundesbank (1998), as well as the current reports in the periodical Wirtschaft und Statistik published by the Federal Statistical Office.

Table 2: The Consumer Price Index in western Germany

Base-year	Published	Reporting month	Retroactive calculation back to	Original calculation up to	In a long series from ... to	Number of household members in base year	Consumption expenditure in DM per month in base year	Number of price representatives
1962	04/1969	03/1969	01/1962	09/1973	1962-1967	2.7	730	879
1970	10/1973	09/1973	01/1968	10/1979	1968-1975	2.7	1294	899
1976	12/1979	10/1979	01/1976	03/1984	1976-1979	2.6	2326	778
1980	05/1984	04/1984	01/1980	09/1989	1980-1984	2.4	2665	753
1985	10/1989	09/1989	01/1985	08/1995	1985-1990	2.3	3105	751
1991	09/1995	08/1995	01/1991	continuing	1991-			approx. 750

Source: Wirtschaft und Statistik, various editions.

new goods are likely to be smaller in the long series of the Consumer Price Index than in current inflation measurement.

The general structure of the weights is derived from the SAMPLE SURVEY OF INCOME AND EXPENDITURE;[1] the figures for the base year are then updated by the results of the CONTINUOUS FAMILY BUDGET SURVEYS. The bundles of goods representative of the three household types are also obtained from these calculations.

Since 1991 the basket of goods has been made up of approximately 750 items. Up to the mid-1970s, it had included another 150 items. At first glance, this gives the impression that the scope of the observations undertaken has been diminished. According to the Federal Statistical Office, however, the exact opposite is the case. Although the number of the index items has been reduced, the number of price series has been increased. However, price series have been combined for publication to a greater extent in order to ensure confidentiality.

For weighting, total expenditure is allocated to the items of the basket of goods in accordance with the 1983 edition of the CLASSIFICATION OF PRIVATE HOUSEHOLDS'

1 For these sample, approximately 45.000 western German households keep a detailed record of their income and expenditure for one year.

INCOME AND EXPENDITURE (SEA).[1] Thus, German price statisticians follow the PRINCIPLE OF REPRESENTATIVE WEIGHTING which means that the total amount spent on a certain purpose of use is assigned to a limited number of selected goods (also known as PRICE REPRESENTATIVES). This is a useful method of reducing the input required for collecting the data when the prices of a product included in the basket of goods and of the other goods thus represented move more or less in line.

In the SEA classification, expenditure, and thus the goods, are classified by their PURPOSE OF USE, then according to their DURABILITY and, finally, their VALUE.[2] A classification in terms of characteristics which affect price movements is done exceptionally in the case of goods whose prices are formed under special circumstances, such as administered prices or prices for goods that are subject to particularly high consumption taxes. There is no direct aim at classification by price and income elasticities, or, indeed, by the degree of the closeness of the substitution relationship. However, it is assumed that cost components or substitution features which are of the same kind result in similar price trends.[3] In many cases, however, this does not apply to new goods (see Chapter V); this could result in a bias.

The selection of price representatives is updated every five years by means of a REVISION OF THE LIST OF GOODS ON WHICH DATA IS TO BE COLLECTED. This is undertaken a long time prior to the conversion to a new base year, so that the prices needed for the retroactive calculation of the index back to the new base year can be collected. When the basket of goods is updated, the product specifications, too, are adjusted to market trends.

In line with the frequency of reporting, the prices of most price representatives are collected once a month. Exceptions to this rule apply mainly to dwellings, in whose case only one-third is used at any one time as a basis for the collection of new prices. Foodstuffs which are not on sale throughout the year have special features, too. As a rule, prices should be collected precisely on the 15th day of a given month.[4] An exception to this rule can be made in the case of goods whose prices change only at longer intervals; prices of

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1 Up to and including the 1976 basket of goods, the items were allocated on the basis of the 1963 edition of the Classification of Goods for Private Consumption.

2 Statistisches Bundesamt (1983).

3 See Danner (1975).

4 Statistisches Bundesamt (1990).

goods with short-term fluctuations, however, must be collected exactly on the reporting day. The final results are published with a time-lag of not quite three weeks.

The collection of prices for about 650 out of the 750 or so price representatives is undertaken by the STATISTICAL OFFICES OF THE LOCAL AUTHORITIES, and, in exceptional cases, by the STATISTICAL OFFICES OF THE LÄNDER. The prices of nation-wide suppliers - such as mail-order houses - are collected directly by the FEDERAL STATISTICAL OFFICE. The number of individual prices per price representative varies according to the degree to which the respective goods and services are disseminated over the reporting municipalities, and to the latter's number of inhabitants. At present, 118 municipalities of all size categories (but with a minimum of 5.000 inhabitants) participate in the price surveys in Germany. However, prices for the entire range of index items are not collected in all municipalities. For example, in a municipality without an opera house of their own, the price of a visit to the opera in the nearest major town or city is not collected - the item is neither recorded nor replaced by another. A total of approximately 250.000 price series has latterly been maintained for the Consumer Price Index in western Germany.

As in the selection of price representatives, the reporting units are selected by the PROCEDURE OF "TYPICAL CASES" (purposive selection), too. This procedure provides for the various types of outlets being taken into account according to their market shares. In addition, when the outlets are selected, their appropriate geographical location in each municipality (town centre, suburbs) are to be considered.

From the individual reports on prices, AVERAGE PRICES OF THE REPORTING MUNICIPALITIES are initially calculated, which are then condensed into AVERAGE PRICES FOR THE LÄNDER.[1] This means that a RATIO OF AVERAGE PRICES (A DUTOT INDEX), not an arithmetic or geometrical mean of rates of price change, is calculated in the aggregation at the micro-level.[2]

Although these average prices are formally unweighted, in the view of the Federal Statistical Office they can broadly be considered as self-weighted by population density owing to their regional distribution. It is not possible to verify how far this is accurate without any detailed information on the reporting municipalities and the number of reporting units.

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1 See Guckes (1976).

2 For a discussion of the various methods of aggregation at the micro-level, see the German version of the discussion paper, p. 25 ff., and the literature cited there, or, for example, Oulton (1998).

However, no such data have been published so far. The average prices for the Länder are then used for calculating INDEX FIGURES FOR THE LÄNDER (ratios of current and base period average prices). Weighted by population ratio, these index figures are combined in a FEDERAL INDEX FIGURE and are used for calculating the Consumer Price Index with the expenditure ratios of the base period according to the formula of the modified Laspeyres index.

For calculating the second major consumer price index, the DEFLATOR FOR PRIVATE CONSUMPTION from the national accounts, private consumption expenditure is initially broken down according to two-digit goods numbers from the SEA. These partial aggregates are deflated with the aid of the corresponding subindices of the Consumer Price Index; the obtained real values are then added together. The implicit deflator is then calculated by dividing the nominal value by the real value of private consumption.[1] Thus, the private consumption deflator is not a true Paasche index.

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1 See Angermann/Stahmer (1976), and Eichmann (1978).

III. The Product Substitution Bias

1. Methods and Earlier Studies

At constant relative prices, the change in any given price reliably measures the aggregate rate of price change. If, however, the prices of individual goods move differently, the question arises as to how these prices can be summarised meaningfully to estimate an overall rate of inflation. Different results may be obtained depending on the index formula and the weights which are chosen.[1] However, there is broad agreement on the fact that the changes in prices of individual goods must be taken into account according to their economic importance. From the consumer's point of view, this would mean the importance of individual goods in private consumption. An IDEAL PRICE INDEX from an individual consumer's point of view would compare the minimum expenditure E for two different price systems p^0, p^t, which, given an otherwise unaltered environment, would be needed to reach a certain level of satisfaction u:[2]

$$(1) \qquad P_C^{t,0} = \frac{E(p^t, \bar{u})}{E(p^0, \bar{u})}$$ [3]

Therefore such an index figure is often also referred to as COST-OF-LIVING INDEX[4] (COLI).

Although it is feasible to specify such an index concept as an ideal for statistical offices, it is hardly practicable for several reasons. Firstly, apart from the knowledge of the prices which are generally observable in principle, a COLI would strictly speaking also presuppose knowledge of individual preferences. Secondly, a problem arises of aggregation across a range of consumers with differing preferences. Owing to the difficulties associated with the COLI, statistical offices therefore start from a different concept in inflation meas-

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1 For an overview of the problem of indices, see Haberler (1927), Diewert (1987), Hill (1988) and (1993).

2 See Konüs (1939), Pollak (1971), Samuelson/Swamy (1974).

3 In this formula the index figure is exactly 1 if the cost of living remains unchanged. Usually, however, indices are standardised to 100 in the base period. The corresponding multiplication by 100 is omitted in the presentation below.

4 Such a cost-of-living index does not capture the additional costs of an increasing standard of living but rather the additional costs of a given level of satisfaction.

urement: they try to isolate "uncontaminated" PRICE CHANGES by asking "How much more does a given bundle of goods cost today than it did x years ago?". Such an index is often referred to as a CONSUMER PRICE INDEX (CPI). If the corresponding quantity structure stems from a base in the past, this approach leads to a LASPEYERES INDEX. In this index a notional sum of expenditure of the present (quantities consumed in the base period x_i^0 valued at prices of the present p_i^t) is compared with a sum of expenditure for the basket of goods in the base period:

$$(2) \qquad P_L^{t,0} = \frac{\sum_i p_i^t x_i^0}{\sum_i p_i^0 x_i^0}$$

Such indices are usually employed in the MONTHLY PRICE STATISTICS and for CURRENT INFLATION MEASUREMENT, since they can generally be compiled with little time lag and at low cost, which is due to the fact that only current data on prices, rather than on consumers' purchasing habits, are needed.[1]

In contrast to an ideal index, a Laspeyres index disregards the fact that many products serve similar consumption purposes and can therefore be substituted for each other. When the relative prices of such products change, consumers can improve their situation by switching to those goods which have become relatively cheaper. The bias resulting from the gap between a Laspeyres index and an ideal index is therefore called a SUBSTITUTION BIAS. This measurement bias thus occurs precisely in those cases in which, firstly, relative prices change and, secondly, consumers react to these changes. For a lasting divergence between a Laspeyres index and a true COLI, however, temporary changes in relative prices are not sufficient. If that were the case, consumers would return to their old bundle of goods for a given level of satisfaction, with the result that a Laspeyres index would again correctly indicate the aggregate rate of price change against the base period. If the diverging price trends are permanent, however - and the differing trends in productivity in the individual sectors of the economy, in particular, argue in favour of that - the COLI and the Laspeyres

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1 In statistical practice, price indices are not calculated using data on quantities consumed. Rather, MODIFIED LASPEYRES INDICES are employed, weighting changes in prices for individual goods by EXPENDITURE SHARES. The following is obtained by a simple transformation from the original Laspeyres index:

$$P_L^{t,0} = \frac{\sum_i p_i^t x_i^0}{\sum_i p_i^0 x_i^0} = \frac{\sum_i \frac{p_i^t}{p_i^0} p_i^0 x_i^0}{\sum_i p_i^0 x_i^0} = \sum_i a_i^0 \frac{p_i^t}{p_i^0} \qquad \text{where} \quad a_i^0 = \frac{p_i^0 x_i^0}{\sum_i p_i^0 x_i^0}$$

index should increasingly diverge from each other in the long term, and the SUBSTITUTION BIAS will increase continually over time.

From considerations of this kind, it is often concluded that a Laspeyres price index sets a ceiling for the true rate of inflation between two points in time. However, these conclusions do not fully take into account the fact that this feature relates only to the reference basket of goods in question.[1] As changes in prices and income interact over time, it is often the case that, alongside substitution effects, INCOME EFFECTS arise which are generally indeterminate in terms of their sign. There is thus nothing to argue against the possibility of there being greater demand for goods which have become more expensive rather than those which are now relatively cheaper in order to achieve a higher level of satisfaction regardless of any substitution opportunities. In that case, however, a COLI which focuses on the higher level of satisfaction of the present, could be above a Laspeyres index when two periods are being compared.

Diewert (1976) showed that, in the case of homothetic preferences, it is quite possible to approximate a COLI by a geometric mean from Laspeyres and Paasche indices (FISHER'S IDEAL INDEX):

$$(3) \qquad P_F^{t,0} = \left(P_L^{t,0} P_P^{t,0}\right)^{\frac{1}{2}} = \left(\frac{\sum_i p_i^t x_i^0}{\sum_i p_i^0 x_i^0} \frac{\sum_i p_i^t x_i^t}{\sum_i p_i^0 x_i^t}\right)^{\frac{1}{2}} = \left(\frac{\sum_i a_i^0 \frac{p_i^t}{p_i^0}}{\sum_i a_i^t \frac{p_i^0}{p_i^t}}\right)^{1/2}$$

According to the terminology used by Diewert (1976), such a Fisher index is also a SUPERLATIVE INDEX, since it represents an accurate index formula for what is known as a FLEXIBLE AGGREGATOR FUNCTION (in this case, a homogenous quadratic function).[2] Diewert terms a function flexible if it allows a second-order approximation for any arbitrary twice-continously-differentiable linear-homogenous utility function. From a practical point of view, these findings represent a major advance, as they have helped to make known index formulas that allow a good approximation of the true index for a large class of preferences.[3] Hence, such a superlative price index is approximately free of any substitution bias.

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1 See Haberler (1927), Konüs (1939), Pollak (1971), Samuelson/Swamy (1974).

2 See also Diewert (1987).

3 See Hill (1988).

Another superlative index formula even offers a rather good approximation in the case of any non-homothetic preferences. This is the TÖRNQVIST INDEX, which is calculated as a geometric mean of the price changes that have been weighted by the average of the base period and current period expenditure shares:[1]

$$(4) \qquad P_T^t = \prod_i \left(\frac{p_i^t}{p_i^0} \right)^{\frac{1}{2}\left(a_i^0 + a_i^t\right)}$$

The Törnqvist index constitutes an accurate index for a TRANSLOG UTILITY FUNCTION. Diewert (1978) furthermore showed that the Fisher and the Törnqvist indices approximate one another quite well in respect to a common starting point.

These superlative indices can be calculated with reference to one particular base year, in which case each (annual or monthly) index value indicates the cumulative rate of price increase since the base period. Or, alternatively, price indices are calculated continuously on the basis of the previous period (previous month or previous year), which are then linked in order to obtain a long series. This indices are referred to as CHAIN INDICES.

A large number of studies have been carried out in the past, particularly for the United States, on the substitution bias in the Consumer Price Index. Like its German counterpart, the US CPI is essentially calculated as a modified Laspeyres index using weights which remain fixed over several years, which means that it is likewise vulnerable to a substitution bias.

In assessing the substitution bias, two fundamentally different methods were employed. First, mainly DEMAND SYSTEMS were estimated with exact price indices subsequently being calculated.[2] Consequently, the gap between the thus obtained exact index (for the demand system) and the Laspeyres index is equivalent to the substitution bias.

Later, mainly ALTERNATIVE INDICES WITH A MORE UP-TO-DATE WEIGHTING were calculated, partly as superlative indices with reference to a fixed base period, and partly as chain indices.[3] The margin between the Laspeyres index and the superlative index forms then approximately corresponds to the substitution bias. The change of method was pri-

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1 See Diewert (1976).

2 See Braithwait (1980).

3 See Manser/McDonald (1988), Aizcorbe/Jackman (1993), Shapiro/Wilcox (1997).

marily initiated by the pioneering results obtained by Diewert. A well-known problem with chain indices, however, is that the reference to a fixed level of satisfaction is lost. Moreover, the problem of index drift can occur with chain indices: the chained indices may then be further away from a true index than their original unchained forms.[1]

Such estimates produced the following results for the United States:

- The substitution bias is highly likely to be less than 0.5 percentage point; at all events, however, it will be more than 0.1 percentage point per annum.
- The bias increases with a finer breakdown of overall consumption. For 53 categories of goods, Braithwait (1980) found a bias of 0.1 percentage point per annum; Manser/McDonald (1988) calculated a bias of less than 0.2 percentage point for 101 categories of goods,[2] and Aizcorbe/Jackman (1993) and Shapiro/Wilcox (1997) finally likewise arrive at a bias of just under 0.2 percentage point per year for 207 categories of goods (compared with an experimental Laspeyres index).[3]

  This ESCALATION OF THE BIAS OCCURRING IN A FINER BREAKDOWN is mainly attributable to the fact that, in these calculations, sub-indices from the consumer price statistics serve as prices for those categories of goods, which have not been broken down in further detail. Consequently, if the trend towards diverging prices continues at a lower level of aggregation, too, the bias would become greater even if the substitution behaviour does not change. In addition, it might be easier, particularly at a lower level of aggregation, to substitute goods for each other if relative prices change, since goods serving similar consumption purposes, e.g. pasta and rice are combined in each of the individual categories. By contrast, the substitution elasticities between cars and fruit, for example, are likely to be small.[4] The deviation between the true rate of inflation and a Laspeyres index can therefore be traced only in expenditure with a very detailed breakdown.

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1 See Forsyth/Fowler (1981), Szulc (1983).

2 Manser/McDonald (1988) also calculate the bias for data that had been aggregated to a higher degree, resulting in a sharp reduction in the bias.

3 Compared with the official CPI, Shapiro/Wilcox (1997) arrive at an average deviation of 0.3 percentage point per annum.

4 Goods that have similar consumption characteristics necessarily constitute closer substitutes than goods which serve completely different consumption purposes [See Lancaster (1966)].

- The various forms of the superlative indices, be they chain-linked or otherwise, produce very similar results.[1] At first glance, this is a remarkable result, as a Törnqvist index, in contrast to a Fisher index, also allows non-homothetic preferences, and chain-linked indices, unlike indices with a fixed base, are focused on variable levels of satisfaction. However, Diewert (1978) showed that the various forms of superlative indices approximate each other well.

Similar results for the substitution bias were obtained by Généreux (1983) for Canada, Balk (1990) for the Netherlands, and Silver/Ioannidis (1994) for nine European countries; in the last case, the deviations between the Laspeyres index and a superlative formula were very small, especially in the case of Germany. For Portugal, finally, Neves/Sarmento (1997) calculated a substitution bias of between 0.05 and 0.1 percentage point per annum.

For GERMANY, Neubauer (1995) compared a PAASCHE INDEX with a Laspeyres index, using the weights of the basket of goods at the three-digit level of the SEA (i.e. approximately 220 categories of expenditure) for approximating the Paasche index. Neubauer arrived at an average deviation of the Laspeyres index from the Paasche index of 0.09 percentage point per annum; for foodstuffs alone (60 categories of expenditure), this figure was less than 0.05 percentage point. In his study, Neubauer also refers to the Federal Statistical Office's calculation of a LASPEYRES CHAIN INDEX for the years 1985 to 1994.[2] For this special calculation, the current weights were taken from the national accounts; as was the case with Neubauer's calculations, the breakdown was limited to the three-digit level. The average of the nine years considered showed no significant deviations between a Laspeyres index with a fixed basket of goods and a chain index.

Finally, the Consumer Price Index can also be compared with the DEFLATOR FOR PRIVATE CONSUMPTION from the national accounts (see Chart 1); although the deflator rose in the long term at a slightly slower pace than the price index, these differences amount to no more than between 0.005 and 0.06 percentage point (see Table 3).

These comparisons indicate that the substitution bias tends to be low in Germany, too; in methodological terms, however, they are not convincing:

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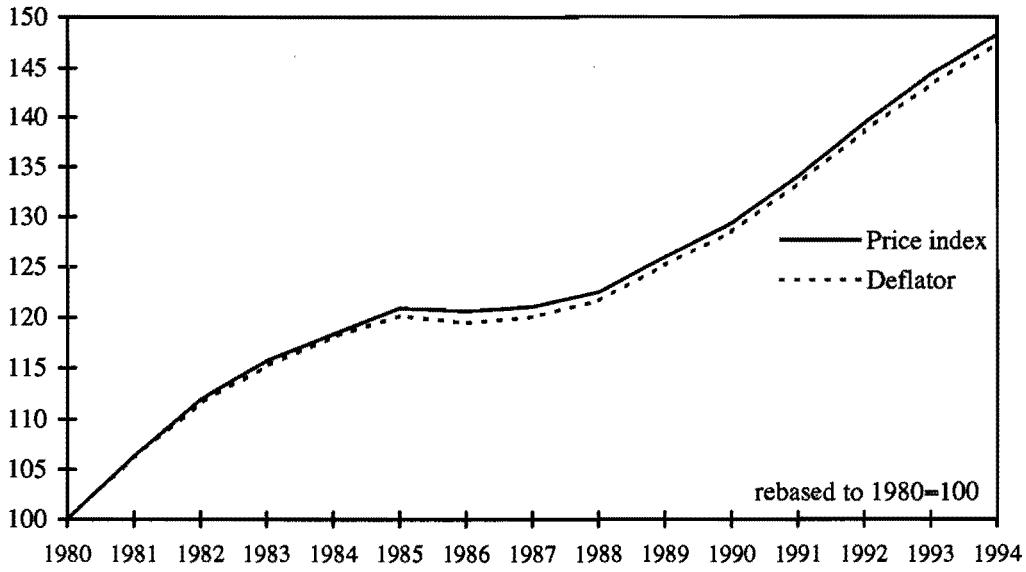
1 Diewert (1978) arrived at the same results with data for Canada, as did Hansen and Lucas (1984) with foreign trade data for Egypt over a very long period from 1885 to 1961!

2 For details, see Schmidt (1997).

Chart 1: Aggregate price trends in western Germany according to the Consumer Price Index and the Deflator for Private Consumption



- It is true that a chain-linked Laspeyres index is usually closer to a true COLI than a Laspeyres index with a fixed base; if the drift problem arises, however, it can move further away from the COLI. Therefore, it would seem prudent to measure the substitution bias against a superlative index.
- A Paasche index can indicate a lower limit for the true rate of price increase; the Laspeyres index can indicate a ceiling. However, these characteristics apply only to a given level of satisfaction. Hence, a comparison between a Paasche index and a Laspeyres index is initially of little informative value for defining the substitution bias. This applies even more in the case of the price index for private consumption from the national accounts, which relates to total private consumption, including that of the non-profit institutions and of people living in institutions.

Table 3: The average rate of price change according to the price statistics and the National Accounts

Period	Average change (in % p.a.)		Average deviation (in percentage points p.a.)
	Consumer Price Index	Deflator for Private Consumption	
1980-1984	4.3	4.2	0.06
1985-1990	1.4	1.4	0.005
1991-1994	3.4	3.4	0.03

2. Case Study No. 1: Experimental Consumer Price Indices for Western Germany

The following index calculations draw on the CONTINUOUS FAMILY BUDGET SURVEYS as a source of annually changing expenditure patterns. For these statistics, a maximum of 1,000 households in western Germany, which have been categorised into three types,[1] keep a finely detailed record of their monthly expenditure. Owing to the rather small number of households, the results may be representative of the population as a whole only to a limited extent. However, other information is not available so that official price statisticians draw on this source of data, too. Electronic media provide data on private households' receipts and expenditure from 1986 onwards,[2] in accordance with the classification introduced in 1983. The index calculations undertaken are therefore limited to the period between 1986 and 1996. This is not a drawback insofar as the typical life of a given basket of goods, during which a bias might build up, is nine years. The price index figures for the individual groups of expenditure were partly obtained from the official consumer price statistics. Subindices from the Consumer Price Index perform this function for parts of expenditure that were aggregated to a larger extent.[3]

With these data, it was possible to calculate experimental Laspeyres, Paasche, Fisher, and Törnqvist indices, firstly with a fixed basis, secondly in a chain-linked form. This was done for annual and monthly figures. In the case of the chain-linked indices, experiments with monthly changing weights were undertaken, too. After a short time, however, a drifting of the indices occurred, rendering an interpretation of these results meaningless. For this reason, the following discussion is confined to annual figures, which are based on annual average figures for expenditure and prices. In the case of expenditure, average figures were normally calculated across the three groups of households. In line with the methods

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1 HOUSEHOLD TYPE 1: Two-person households of pensioners or recipients of social assistance (average monthly net income in 1996: DM 2,650); HOUSEHOLD TYPE 2: Four-person households of salary or wage earners with a middle income of a married sole earner (average monthly net income in 1996: DM 5,203); HOUSEHOLD TYPE 3: Four-person households of civil servants or salary earners with higher income (average monthly net income in 1996: DM 8,122).

2 See www.statis-bund.de.

3 POTATO PRICES are an important exception here. In control calculations using unit values from the Continuous Family Budget Surveys, it emerged that the price index for potatoes is considerably distorted upwards owing to chain-linking errors. Therefore, in the index calculations for foodstuffs, which are broken down in greater detail, the index figure series for potatoes taken from the Consumer Price Index was substituted by an series of unit values obtained from the Continuous Family Budget Surveys.

adopted by the Federal Statistical Office, however, price indices were also calculated separately for each of the three groups of households.

In order to assess the significance of the base year for price indices obtained from fixed baskets of goods, 11 EXPERIMENTAL LASPEYRES INDICES were initially calculated, each of which was based on the expenditure pattern during one of the years of the period under review (Table 4). After ten years, more pronounced differences are discernible in the case of the index levels corresponding to the cumulative rate of price change in this period; in a year-on-year comparison, however, the individual indices follow a similar pattern. The shifts in consumption patterns during the period under review are nowhere near dramatic enough for the choice of a given base year to have a significant impact on the recorded rate of inflation.

Nevertheless, it is not possible to compare the experimental Laspeyres index with the Consumer Price Index based on the year 1985 without some reservations. Rather than calculating simple averages of expenditure shares, as has been done in the present paper, the Statistical Federal Office extrapolates the results of the Continuous Family Budget Surveys for the population as a whole, using detailed data from the Sample Survey of Income and Expenditure. Furthermore, the official statistics raise the figures for expenditure on tobacco and spirits,[1] as these are systematically quoted too low in the surveys.[2] Therefore, the rate of price increase indicated in the official Consumer Price Index is somewhat higher than in the experimental Laspeyres indices (Table 4) during the period under review. The cyclical trends in the individual price indices are very similar, however.

As a first step in determining the substitution bias, different price indices were calculated for a BREAKDOWN OF CONSUMPTION EXPENDITURE AMONG 54 CATEGORIES (Table 5). During the period under review, virtually no deviation between the various index forms was observed. Only the chain-linked indices were around one-tenth below the experimental Laspeyres index after ten years. The average bias at this level of aggregation is therefore no more than approximately 1/100 percentage point per year. One would have expected the bias at this level of aggregation to be very low; a result near to nil is nevertheless surprising.

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1 See Guckes (1964).

2 See Euler (1974), Hertel (1997).

Table 4: Experimental Laspeyres indices for private households' consumption (54 categories of expenditure)

1986=100	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Consumer Price Index (1985)	100.1	101.4	104.2	107.0	110.7	115.1	119.9	123.5	-	-
Consumption pattern in 1986	100.1	101.1	103.9	106.9	110.7	114.9	118.8	121.9	124.0	125.8
Consumption pattern in 1987	100.2	101.3	104.0	106.9	110.8	115.0	118.9	122.0	124.2	126.0
Consumption pattern in 1988	100.3	101.4	104.2	107.1	111.0	115.2	119.2	122.3	124.5	126.4
Consumption pattern in 1989	100.3	101.3	104.2	107.1	111.0	115.2	119.2	122.4	124.6	126.6
Consumption pattern in 1990	100.3	101.4	104.2	107.1	111.1	115.3	119.3	122.5	124.7	126.6
Consumption pattern in 1991	100.3	101.4	104.2	107.2	111.1	115.3	119.3	122.5	124.7	126.6
Consumption pattern in 1992	100.4	101.5	104.3	107.2	111.1	115.4	119.5	122.6	124.8	126.7
Consumption pattern in 1993	100.4	101.5	104.3	107.2	111.1	115.4	119.5	122.8	125.0	127.0
Consumption pattern in 1994	100.4	101.5	104.4	107.3	111.2	115.6	119.7	123.1	125.3	127.3
Consumption pattern in 1995	100.4	101.6	104.5	107.4	111.4	115.8	120.0	123.4	125.7	127.7
Consumption pattern in 1996	100.5	101.6	104.5	107.5	111.5	115.9	120.1	123.5	125.8	127.9
Change against previous year in %										
Consumer Price Index (1985)	0.2	1.3	2.8	2.7	3.5	4.0	4.2	3.0	-	-
Consumption pattern in 1986	0.1	1.0	2.8	2.8	3.6	3.7	3.4	2.6	1.7	1.5
Consumption pattern in 1987	0.2	1.0	2.7	2.8	3.6	3.8	3.4	2.6	1.8	1.5
Consumption pattern in 1988	0.3	1.1	2.7	2.8	3.6	3.8	3.5	2.6	1.8	1.5
Consumption pattern in 1989	0.3	1.1	2.8	2.8	3.6	3.8	3.5	2.7	1.8	1.5
Consumption pattern in 1990	0.3	1.1	2.8	2.8	3.7	3.8	3.5	2.7	1.8	1.6
Consumption pattern in 1991	0.3	1.1	2.8	2.8	3.7	3.8	3.5	2.7	1.8	1.5
Consumption pattern in 1992	0.4	1.1	2.8	2.8	3.7	3.9	3.5	2.6	1.8	1.6
Consumption pattern in 1993	0.4	1.1	2.8	2.8	3.6	3.9	3.6	2.7	1.8	1.6
Consumption pattern in 1994	0.4	1.1	2.8	2.8	3.7	3.9	3.6	2.8	1.9	1.6
Consumption pattern in 1995	0.4	1.2	2.9	2.8	3.7	4.0	3.6	2.8	1.9	1.6
Consumption pattern in 1996	0.5	1.2	2.9	2.8	3.7	4.0	3.7	2.8	1.9	1.6

Consumer Price Index (1985): Consumer Price Index based on the 1985 basket of goods, rebased to 1986 = 100

Consumption pattern in 19**: Experimental Laspeyres index weighted according to the average consumption pattern in 19**.

Table 5: Experimental price indices for private households' consumption
(54 categories of expenditure)

1986=100	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Laspeyres86	100.1	101.1	103.9	106.9	110.7	114.9	118.8	121.9	124.0	125.8
Paasche86	100.1	101.2	104.0	106.9	110.7	114.8	118.5	121.6	123.9	125.7
Fisher86	100.1	101.2	104.0	106.9	110.7	114.8	118.7	121.7	123.9	125.8
Törnqvist86	100.1	101.2	104.0	106.9	110.7	114.8	118.7	121.7	124.0	125.8
ChLaspeyres	100.1	101.1	103.9	106.8	110.7	114.8	118.7	121.8	123.9	125.7
ChPaasche	100.1	101.1	103.9	106.8	110.6	114.8	118.6	121.7	123.8	125.6
ChFisher	100.1	101.1	103.9	106.8	110.6	114.8	118.7	121.7	123.9	125.7
ChTörnqvist	100.1	101.1	103.9	106.8	110.6	114.8	118.7	121.7	123.8	125.7
Change against previous year in %										
Laspeyres86	0.1	1.0	2.8	2.8	3.6	3.7	3.4	2.6	1.7	1.5
Paasche86	0.1	1.1	2.7	2.8	3.6	3.7	3.3	2.6	1.9	1.5
Fisher86	0.1	1.0	2.8	2.8	3.6	3.7	3.3	2.6	1.8	1.5
Törnqvist86	0.1	1.0	2.8	2.8	3.6	3.7	3.3	2.6	1.8	1.5
ChLaspeyres	0.1	1.0	2.8	2.8	3.6	3.8	3.4	2.6	1.7	1.5
ChPaasche	0.1	1.0	2.8	2.7	3.6	3.8	3.4	2.6	1.8	1.5
ChFisher	0.1	1.0	2.8	2.8	3.6	3.8	3.4	2.6	1.8	1.5
ChTörnqvist	0.1	1.0	2.8	2.8	3.6	3.8	3.4	2.6	1.8	1.5
Average deviation of Laspeyres86 from ... in percentage point per annum										
Paasche86	0.00	-0.03	0.00	0.00	0.02	0.02	0.03	0.03	0.00	0.00
Fisher86	0.00	-0.02	0.00	0.00	0.01	0.01	0.02	0.01	0.00	0.00
Törnqvist86	0.00	-0.01	0.00	0.00	0.01	0.01	0.02	0.01	0.00	0.00
ChLaspeyres	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
ChPaasche	0.00	-0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.01	0.01
ChFisher	0.00	0.00	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.01
ChTörnqvist	0.00	0.00	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.01

...86: Index with base year 1986
Ch... : Chain index

On the basis of both the general considerations mentioned above and the results of the US studies, it seems natural to suppose a greater bias to occur when there is a finer breakdown of expenditure. For that reason, as a supplement, different PRICE INDICES FOR FOOD, DRINK, AND TOBACCO with a deeper disaggregation of expenditure were calculated. This was not possible for other groups of goods and for private consumption as a whole, as the Federal Statistical Office does not publish any figures which have been broken down in corresponding detail. In view of the low number of of households participating in the surveys, it would also have been scarcely possible to interpret the results for many groups of goods for which there is no regular demand.[1]

The price indices for foodstuffs were calculated by BREAKING THEM DOWN INTO 91 ITEMS. The deviation between the experimental Laspeyres index and the superlative index formulas is about one-half percentage point or approximately 1/20 percentage point per annum after nine years (Table 6).[2] Although this is significantly more than before, it is still far below the figures obtained by US studies using a similar degree of disaggregation.

In order to illustrate the aggregation effect, further price indices were calculated for food, spirits and tobacco; this time, however, this was done with a less detailed breakdown of expenditure. In conformity with the results obtained for private consumption as a whole, only very small deviations between the various index formulas are discernible (see Table 7).[3]

Finally, the various indices are calculated separately for the THREE HOUSEHOLD TYPES. Table 8 contains extracts from the results. According to these results, especially households with a lower income adjust their consumption patterns to shifts in relative prices, whereas the more prosperous households of civil servants and salary earners tend to adhere to their usual consumption patterns, regardless of any price changes.

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1 See Kunz/Euler (1972).

2 However, if the various indices are calculated with the index figure series for potatoes from the official price statistics, the bias would be twice as high!

3 The comparably large bias obtained in this case is mainly due to the fact that the index figure series for potatoes and vegetables was not adjusted for the bias occurring in potato prices.

Table 6: Experimental price indices for private households' consumption of food, spirits and tobacco (91 categories of expenditure)

1986=100	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Laspeyres86	99.2	98.9	100.6	103.4	106.4	109.5	111.2	112.9	114.2	115.1
Paasche86	99.2	98.8	100.4	103.1	106.2	109.1	110.6	112.1	113.3	114.2
Fisher86	99.2	98.9	100.5	103.2	106.3	109.3	110.9	112.5	113.8	114.6
Törnqvist86	99.2	98.9	100.5	103.2	106.3	109.3	110.9	112.5	113.8	114.6
ChLaspeyres	99.2	98.9	100.5	103.2	106.3	109.3	111.1	112.7	113.9	114.8
ChPaasche	99.2	98.8	100.3	103.0	106.1	109.1	110.8	112.3	113.5	114.4
ChFisher	99.2	98.9	100.4	103.1	106.2	109.2	110.9	112.5	113.7	114.6
ChTörnqvist	99.2	98.9	100.4	103.1	106.2	109.2	110.9	112.5	113.7	114.6
Change against previous year in %										
Laspeyres86	-0.8	-0.3	1.7	2.7	2.9	3.0	1.5	1.5	1.2	0.7
Paasche86	-0.8	-0.4	1.6	2.7	3.0	2.7	1.4	1.4	1.1	0.8
Fisher86	-0.8	-0.3	1.6	2.7	3.0	2.8	1.5	1.4	1.1	0.7
Törnqvist86	-0.8	-0.4	1.6	2.7	2.9	2.8	1.5	1.4	1.2	0.7
ChLaspeyres	-0.8	-0.3	1.6	2.7	3.0	2.9	1.6	1.4	1.1	0.8
ChPaasche	-0.8	-0.4	1.5	2.7	3.0	2.9	1.5	1.4	1.0	0.8
ChFisher	-0.8	-0.4	1.6	2.7	3.0	2.9	1.6	1.4	1.1	0.8
ChTörnqvist	-0.8	-0.4	1.6	2.7	3.0	2.9	1.6	1.4	1.1	0.8
Average deviation of Laspeyres86 from ...in percentage point per annum										
Paasche86	0.03	0.05	0.07	0.06	0.04	0.08	0.08	0.08	0.09	0.08
Fisher86	0.02	0.03	0.04	0.03	0.02	0.04	0.04	0.04	0.04	0.04
Törnqvist86	0.02	0.03	0.04	0.04	0.03	0.04	0.05	0.04	0.04	0.04
ChLaspeyres	0.00	0.02	0.04	0.04	0.02	0.03	0.02	0.02	0.03	0.02
ChPaasche	0.03	0.07	0.09	0.08	0.06	0.07	0.06	0.06	0.07	0.06
ChFisher	0.02	0.04	0.07	0.06	0.04	0.05	0.04	0.04	0.05	0.04
ChTörnqvist	0.02	0.04	0.07	0.06	0.04	0.05	0.04	0.04	0.05	0.04

...86: Index with base year 1986
Ch...: Chain index

Table 7: Experimental price indices for private households' consumption of food, spirits and tobacco (9 categories of expenditure)

1986=100	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Laspeyres86	99.5	99.6	101.8	105.1	108.1	111.3	113.2	114.9	116.4	117.5
Paasche86	99.5	99.6	101.8	105.0	108.0	111.1	113.0	114.7	116.3	117.3
Fisher86	99.5	99.6	101.8	105.0	108.1	111.2	113.1	114.8	116.3	117.4
Törnqvist86	99.5	99.6	101.8	105.0	108.1	111.2	113.1	114.8	116.4	117.4
Change against previous year in %										
Laspeyres86	-0.5	0.1	2.2	3.1	2.9	2.9	1.7	1.6	1.3	1.0
Paasche86	-0.5	0.1	2.2	3.1	2.9	2.9	1.7	1.5	1.3	0.9
Fisher86	-0.5	0.1	2.2	3.1	2.9	2.9	1.7	1.5	1.3	0.9
Törnqvist86	-0.5	0.1	2.2	3.1	2.9	2.9	1.7	1.5	1.3	0.9
Average deviation of Laspeyres86 from ... per annum										
Paasche86	0.02	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.01	0.02
Fisher86	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Törnqvist86	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01

...86: Index with base year 1986
Ch... : Chain index

On the whole, these calculations - apart from the absolute figure for the bias - confirm the picture that is familiar from US studies:

- The various superlative indices are closely related, whether they are chain-linked or not.
- The Laspeyres index is above, and the Paasche index is below the superlative indices.
- The chain-linked Laspeyres index is generally below, and the chain-linked Paasche index is often above the corresponding indices with a fixed base.
- In the case of sub-annual chain-linking, a drift in the index occurs.

A further notable result concerns the change in the substitution bias over time. Actually one should expect the average bias to rise as the basket of goods becomes increasingly outdated. However, this is not the case with the experimental indices presented above. Shapiro/Wilcox (1997) obtained a similar result for this period using US data, however. They, too, were unable to offer an explanation for this phenomenon.

Table 8: Experimental price indices for private consumption of food, tobacco and spirits according to household types (91 categories of expenditure)

1986=100	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
HOUSHOLD TYPE 1: Two-person households of pensioners or recipients of social assistance										
Laspeyres86	99.0	98.5	100.2	103.0	106.1	109.0	110.4	112.1	113.6	114.2
Törnqvist86	98.9	98.3	100.0	102.8	105.8	108.6	109.8	111.6	113.1	113.8
ChTörnqvist	98.9	98.3	100.0	102.7	105.8	108.5	109.9	111.5	112.9	113.6
Change from previous year in %										
Laspeyres86	-1.0	-0.5	1.8	2.8	3.0	2.7	1.3	1.5	1.3	0.5
Törnqvist86	-1.1	-0.6	1.7	2.8	2.9	2.6	1.2	1.5	1.3	0.6
ChTörnqvist	-1.1	-0.6	1.7	2.7	3.0	2.6	1.3	1.5	1.2	0.6
Average deviation of Laspeyres86 from ... in percentage point per annum										
Törnqvist86	0.07	0.07	0.07	0.06	0.05	0.07	0.07	0.06	0.05	0.04
ChTörnqvist	0.07	0.10	0.09	0.08	0.06	0.08	0.07	0.07	0.07	0.06
HAUSHOLD TYPE 2: Four-person households of salary or wage earners with a middle income										
Laspeyres86	99.2	98.9	100.6	103.4	106.3	109.6	111.4	113.0	114.4	115.3
Törnqvist86	99.2	98.9	100.5	103.2	106.2	109.4	111.0	112.6	113.9	114.7
ChTörnqvist	99.2	98.9	100.4	103.1	106.1	109.3	111.1	112.7	113.8	114.8
Change from previous year in %										
Laspeyres86	-0.8	-0.3	1.7	2.8	2.9	3.1	1.6	1.5	1.2	0.8
Törnqvist86	-0.8	-0.3	1.6	2.7	2.9	3.0	1.5	1.4	1.1	0.7
ChTörnqvist	-0.8	-0.3	1.6	2.7	2.9	3.0	1.6	1.4	1.0	0.8
Average deviation of Laspeyres86 from ...in percentage point per annum										
Törnqvist86	0.01	0.01	0.03	0.03	0.03	0.04	0.05	0.05	0.05	0.05
ChTörnqvist	0.01	0.03	0.06	0.07	0.04	0.05	0.04	0.04	0.05	0.04
HOUSHOLD TYPE 3: Four-person households of civil servants or salary earners with higher income										
Laspeyres86	99.4	99.2	100.8	103.5	106.8	109.7	111.5	113.1	114.4	115.3
Törnqvist86	99.4	99.1	100.7	103.4	106.5	109.5	111.3	112.8	114.1	115.0
ChTörnqvist	99.4	99.1	100.6	103.3	106.4	109.5	111.3	112.9	114.0	115.0
Change from previous year in %										
Laspeyres86	-0.6	-0.2	1.6	2.7	3.0	3.0	1.6	1.4	1.1	0.8
Törnqvist86	-0.6	-0.3	1.6	2.7	3.0	2.8	1.6	1.4	1.1	0.8
ChTörnqvist	-0.6	-0.3	1.5	2.7	3.0	2.9	1.6	1.4	1.0	0.9
Average deviation of Laspeyres86 from ... in percentage point per annum										
Törnqvist86	0.00	0.02	0.03	0.03	0.01	0.03	0.03	0.03	0.03	0.03
ChTörnqvist	0.00	0.03	0.06	0.05	0.03	0.04	0.02	0.03	0.04	0.03

...86: Index with base year 1986 Ch...: Chain index

3. Results and Extrapolation

It has been seen that, if the expenditure on FOOD is broken down into 91 categories, the substitution bias for the average of the three household types is around 1/20 PERCENTAGE POINT PER ANNUM. At first sight, this may appear to be very little; however, it has to be borne in mind that even at such an aggregation level, consumption expenditure is still broken down into quite roughly-defined categories, such as beef or pork. Corresponding Laspeyres indices frequently function as prices for this aggregated expenditure.[1] It is therefore quite probable that greater deviations between the Laspeyres index and other index forms would be discovered with a finer breakdown of conssumption.

Furthermore, it would be necessary to examine whether this result is applicable to the entire basket of goods. As reliable detailed data on shifts in consumption patterns for other categories of goods cannot be obtained from the Continuous Family Budget Surveys, only more or less well-founded speculation is possible. The results obtained for the United States[2] and for Canada[3] indicate that the substitution bias for other components of the basket of goods is considerably higher than that for food. This is lent support by the fact that the total figure is significantly higher than the substitution bias for food alone. If these relationships are applied to Germany, and if the estimate for the bias for food is also taken into account, a SUBSTITUTION BIAS TOTALLING AT LEAST 0.05, BUT MORE LIKELY TO BE 0.1 PERCENTAGE POINT PER ANNUM can be expected to occur in the Consumer Price Index for Western Germany.

A more precise estimate of the substitution bias contained in the German Consumer Price Index would only be possible with more finely disaggregated data on private consumption. However, such data are unavailable from official sources annually.[4] Even if the situation regarding data were more favourable, statisticians would still be restricted to the 750 or so items of the Consumer Price Index, whereas many thousands of goods exist in reality. However, the question arises of whether the substitution bias in a Laspeyres index with a

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1 At the lowest level of aggregation a Dutot index (ratio of averages) is calculated in Germany.

2 See Braithwait (1980).

3 See Généreux (1983).

4 Although such finely-categorised data are collected in Sample Survey of Income and Expenditure, these surveys are undertaken only every five years. A solution would be to calculate alternative price indices for five-year intervals, or to try to generate such values for the years between the surveys using different data sources. However, examining these options must be left to future studies.

correspondingly large number of goods would also be correspondingly larger, perhaps in the order of one percentage point? The following points argue against this: given a finer breakdown of expenditure, a higher number of close substitutes can be found (such as various types of refrigerators), and any other substitution gaps are closed (for example if, besides refrigerators and deep-freezers, combined appliances are on the market). However, for a major substitution bias to develop, the various products' price trends would have to diverge over the long term, and this is unlikely to occur with regard to many close substitutes because their production technologies are largely similar. The extent of a substitution bias would therefore be limited, even in the case of a very finely disaggregated basket of goods.

Moreover, it generally is the case that, in the common definition, the substitution bias is related to a basket of goods with a given breakdown; any further bias due to differing price trends of goods that were not included in inflation measurement would have to be classed as the new product bias in accordance with our definition of the differences between a Laspeyres index and an ideal COLI. With a very fine disaggregation of private consumption in the basket of goods of the consumer price index, the substitution bias would be greater; at the same time, the bias for new products that affects goods and services that are not included and which have differing price trends, would be correspondingly lower. Much the same would apply if the basket of goods were to be broken down by type of business; in that case, the product substitution bias would increase at the expense of the outlet substitution bias.

In many countries ITEM PRICE INDICES are calculated as modified Laspeyres indices. This means that there might be a further SUBSTITUTION OR FORMULA BIAS AT THE LOWEST LEVEL OF AGGREGATION.[1] A substitution of the modified Laspeyres index by a geometric mean formula, which allows for some substitution, tends to reduce the recorded rate of inflation in these countries.[2] In Germany, however, item price indices are calculated as DUTOT PRICE INDICES. Such relatives of averages of prices might give higher or lower rates of price increases as the geometric mean formula, depending on the distribution of prices in the base period and the current period.[3] Lacking detailed information, at this moment we do not know whether there is an additional lower level substitution bias in Germany.

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1 See Carruthers/Sellwood/Ward (1980), Reinsdorf (1998).

2 See Moulton (1993), Oulton (1998).

3 See Baxter (1997) and Dalén (1998).

IV. The Quality Change Bias

1. Problems of Inflation Measurement when the Range of Goods Available is Changing

> "One does not wish to speak of an increase in price if a good has simultaneously improved to the same extent ..."
> Horstmann (1963)

Comparing prices over time makes sense, strictly speaking, only for goods that do not change. However, in dynamic economies, this restriction cannot be maintained over a longer period, as the range of goods available is constantly changing. In that case, either an intertemporal comparison of prices is dispensed with or other solutions must be found in order to fulfil approximately the requirement of a constant quality of products.

A distinction is usually made between two cases, depending on the degree of the change of the range of goods available:

- Although a new good differs from the predecessor models, its essential characteristics remain unchanged. This is the case, say, if a new refrigerator which consumes less electricity comes on to the market. This is referred to below as a NEW MODEL or a CHANGE IN THE QUALITY of an established good.
- A new good differs essentially from the goods previously on the market which satisfy similar needs. Examples of this are microwave ovens in comparison with electric or gas cookers, or CD players in comparison with record players. In this case, we shall speak of NEW PRODUCTS. Hence new products should not simply be small variations of existing models but rather represent a substantial extension of the product range.

Although, from a theoretical point of view, both cases constitute a similar phenomenon, price statisticians treat these two cases quite differently. The reasons for this are mainly practical. At any given time, there are a number of similar goods which differ only slightly from each other. Strictly speaking, they are different products whose prices should be included in a precise index according to their relevance to turnover. This is virtually impossible owing to the large variety of products. Therefore, the different variants of one product are treated as a composite commodity. The relative prices of products that are very similar

are unlikely to change significantly over time, so that such a simplification appears legitimate. In that case, it is usually adequate to monitor the price of a single product variant only.

However, this is scarcely feasible over longer periods. In the case of many manufactured products, for example, annual MODEL CHANGES are usual; sometimes model changes occur even more frequently. In the case of clothing, fashion changes at least twice per year in line with the seasons; furthermore in most cases an old model is replaced by a new model. Therefore price statisticians have no choice but continually to link the price series for old models and those for new ones. In that case, comparisons of prices over longer periods are meaningful only if the monetary value of the qualitative difference is estimated and taken away from the difference in price between the new and the old variants. This means that the price difference must be divided into a TRUE CHANGE IN PRICE and a (monetary) equivalent of the CHANGE IN QUALITY. The importance of this problem is highlighted by the fact that in US consumer price statistics the changeover to new product variants accounts for a considerable share of the aggregate US price increase.[1]

A successful NEW PRODUCT, however, typically squeezes out old products from the market only at a slow pace and also, in some cases, to no more than a limited extent. The relationship between new products as substitutes for old ones is not as close as that between new models and old ones. For example, record players continue to be sold, even though their market importance has decreased considerably in comparison with CD players. However, since consumers still possess large stocks of gramophone records, which are a durable complementary product, CD players, which have an overall superior price-performance ratio, cannot displace record players completely. Other examples of a co-existence of old and new products are electric cookers and microwave ovens, as well as fixed telephones and mobile phones.

Comparing prices of old products, such as record players, would therefore be possible as well as meaningful even over longer periods. Owing to their increasing market importance, however, CD players would have to be included in the price index, too. In the case of record players, however, the loss in importance has now become so great that, in terms of measuring inflation in the economy as a whole, their low share in turnover hardly justifies a further (cost-intensive) monitoring of prices.

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1 This was shown as early as 1984 by Armknecht. See Moulton/Moses (1997) for a recent exposition.

Furthermore, growing economies are characterised by an INCREASING PRODUCT VARIETY, which is accompanied partly by changes in quality, and partly by the appearance of new products. The gains in prosperity linked with the enlargement of the range of products available have so far not been considered at all in the price statistics. In principle, the problems this would entail could be solved if the price index were geared to the ideal of an cost of living index. The rate of inflation would then correspond to the change in the minimum expenditure needed to maintain a given standard of living, and the calculation of the cost of living would include not only changed prices but also a changed, perhaps even an extended range of products available.

Owing to the differing treatment of changes in quality and new products in the official statistics, I shall concentrate initially on the way small changes in the quality of products are treated when measuring inflation; Chapter V will then deal with true innovations.

2. Quality Adjustment of Prices in the Consumer Price Index

> "I believe, however, that understanding and analyzing the implications of CPI quality adjustment procedures is important and relevant."
> Jack Triplett (1997)

a) Responsibilities in Capturing and Assessing Quality Changes

The statistical offices have two tasks to perform in connection with changes in product specifications:

- CORRECTLY IDENTIFYING QUALITY CHANGES, and
- CORRECTLY ASSESSING QUALITY CHANGES.

In the Federal Republic of Germany, these tasks are usually performed by the price statisticians of the statistical offices of the Länder and the municipalities, respectively. Only the prices that are collected centrally by the Federal Statistical Office (such as prices for services rendered by insurance companies, in the health sector, in the postal and telecommunications sectors, as well as prices for automobiles and mail-order goods) are adjusted centrally for changes in quality. The quality adjustment of prices is generally coordinated by the GUIDELINES GOVERNING THE CONSUMER PRICE STATISTICS OF THE FEDERAL STATISTICAL OFFICE.[1]

Normally, the Länder report only the unadjusted average prices for the Länder and the quality-adjusted index figures to the Federal Statistical Office. The Federal Statistical Office is therefore unable to make a detailed check of the adjustments that have been made. Only a plausibility analysis of the short-term changes in the Länder index figures is carried out centrally. The assessment of the quality changes can therefore vary considerably. This might have the advantage that the overall result constitutes a "DEMOCRATIC" ASSESSMENT OF QUALITY CHANGES; on the other hand, the average of many assessments that are more or less accurate is not necessarily a reliable estimate of quality change.

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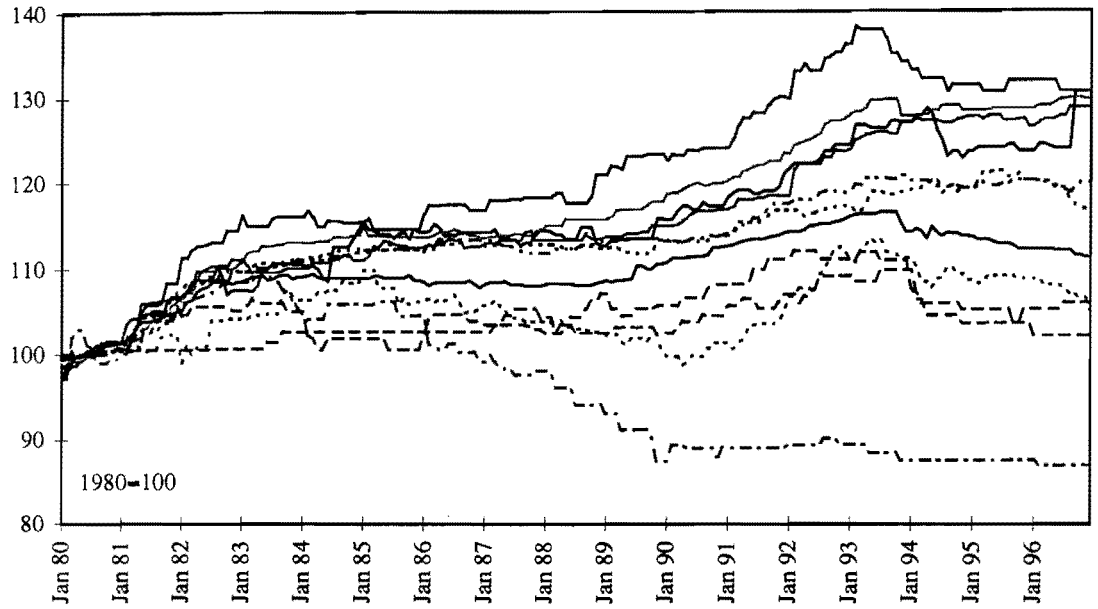
[1] Statistisches Bundesamt (1990). These instructions have now been revised as part of efforts to harmonise European price statistics (see Statistisches Bundesamt (1996)); further adjustments are imminent. The results derived below are therefore valid mainly for the period up to 1996; applying them to the present appears admissible, however, since their essential aspects have remained unaltered, even though the rules to be applied by price statisticians to quality changes have been simplified.

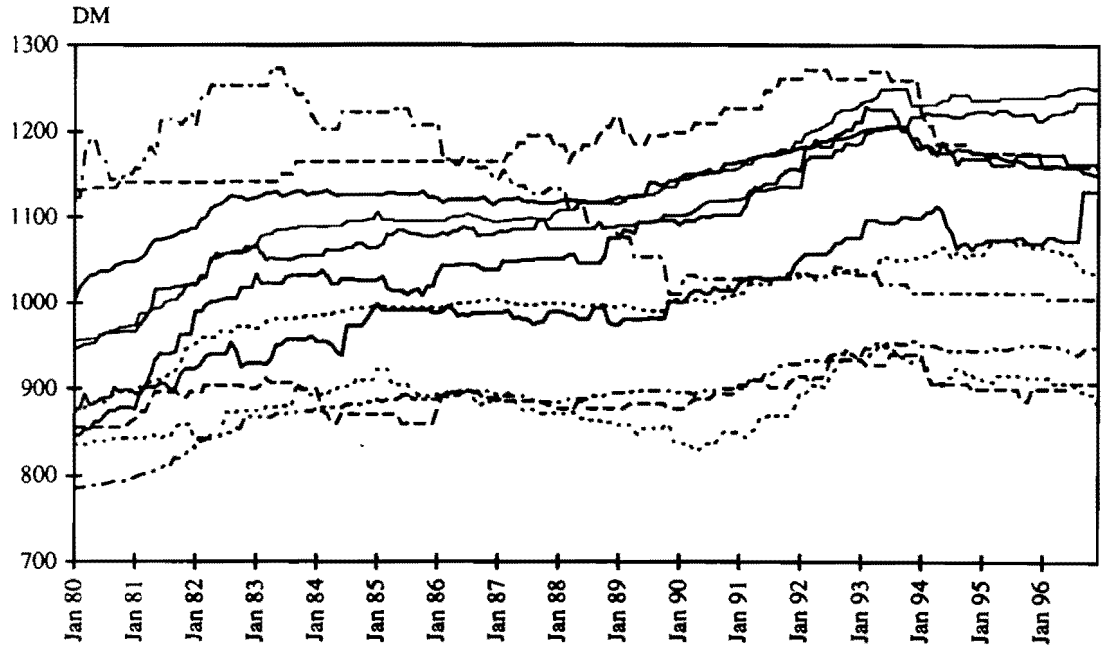
Chart 2: Länder price indices for washing machines in western Germany
(Chain-linked price indices of the baskets for goods of 1980, 1985 and 1991)



Given a consistent assessment of quality changes by the individual Länder, the QUALITY ADJUSTED PRICE INDICES OF THE LÄNDER for nationally traded goods should actually move approximately in step with each other, especially as these Länder index figures are already based on an average of the prices in several municipalities or at least in several outlets. For that reason, the Länder index figures for a number of goods were compared over shorter and over longer periods. For these selected goods, the results obtained for washing machines are quite typical (Chart 2): The price indices of the Länder diverge considerably. In most cases, however, the marginal positions are occupied by the smaller Länder, where the numbers of product variants included in inflation measurement are very small. In 1997, price measurement for the sub-index for washing machines was based on the prices in no more than four outlets in the smallest Land of Bremen; this contrasts with a number of 27 in Bavaria.

However, comparing the quality-adjusted price indices can give a distorted impression of the price statisticians' performance if the price relationships did not correspond to a long-term equilibrium at the beginning of the observation period. For example, expensive outlets then ought to become cheaper. For that reason, the absolute DM prices of the year 1980 were extrapolated with the quality-adjusted price indices (Chart 3). If quality adjustment is consistent, these quality-adjusted price series should no longer diverge on average. At first sight, a more favourable picture is obtained than in the case of the price indices standard-

Chart 3: Extrapolated washing machine prices in the west German Länder
(Average DM prices in January 1980, extrapolated on the basis of quality-adjusted price indices)



ised to 100 on the annual average of 1980. A coefficient of variation weighted by population shares was calculated for both the beginning and the end of the observation period in order to obtain a more precise measure of how close the price series are to each other. Nevertheless, this showed, in fact, that even the Länder prices extrapolated with the quality-adjusted price indices diverge on average both for washing machines and for most of the other products. It is impossible to find the reasons for this divergence without a detailed analysis. As this study was mainly concerned with the measurement bias as a whole, such a detailed analysis was not undertaken. An examination of the Länder price indices for consistency, which would be useful in itself, must therefore be left to future studies.

Since 1997, the requirements for the treatment of quality changes have been amended following the introduction of HARMONISED INDICES FOR CONSUMER PRICES (HICP) in the European Union.[1] Since that time, it has at least been compulsory to record the methods adopted for quality adjustments in a greater detail. In addition, since January 1997 the statistical offices of the Länder have been supplying such data to the Federal Statistical Office so that a centralised collection of data on quality adjustments on a national bias has been made possible for the first time ever. As part of the advancing harmonisation of price indices in Europe and on behalf of the STATISTICAL OFFICE OF THE EUROPEAN COMMUNITIES (EUROSTAT), the Federal Statistical Office has now started to undertake

1 See Elbel (1997), Gottsmann (1997), Statistisches Bundesamt (1996).

detailed analyses of selected goods. As the detailed descriptions of the goods' variants selected for price monitoring are not available on electronic media, however, the Federal Statistical Office is unable to verify whether the quality adjustment has been carried out "correctly" in individual cases.

b) The Selection of the Price Representatives

In principle, difficult assessment problems arise when there is a change to a new model, owing to the associated quality adjustment; for this reason, according to the requirements of the Federal Statistical Office, a price representative should be adhered to for as long as possible once it has been selected.[1] Price statisticians are therefore instructed to select goods as price representatives that are as widely traded as possible and that can be expected to remain on the market for a long time without undergoing any alterations. In general, however, the price statisticians should opt for THE BIGGEST SELLING MODEL rather than, say, a slow seller as their object of price monitoring. A good with a major importance for turnover is generally likely to be sold for a longer period, provided that it has not been marketed for the quick satisfaction of a one-off need. In case of doubt, a medium quality should be selected. If it is not possible to find a model corresponding to the official specification, a good that is as similar as possible and that has a major importance for turnover may be selected.

The relevant factor in the selection of a price representative is the product variant's importance for turnover in the reporting unit (rather than in Germany as a whole). Thus, goods belonging to different market segments are included in the index figures and in the average prices, depending on the purchasing power in the neighbourhood of the selected outlet. The specifications of the goods in the questionnaires are deliberately worded in broad terms in order to allow price statisticians to be flexible in selecting the models with the highest turnover.

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1 For details, see Statistisches Bundesamt (1990).

c) Indirect Methods to Eliminate Quality Changes

According to the requirements of the Federal Statistical Office, only TRUE PRICE CHANGES are to be included in the Consumer Price Index. PRICE CHANGES which do not constitute a true price change are to be eliminated. Whether there has been a change in quality should not be judged on subjective grounds but should be defined by a GENERAL UTILITY VALUE. Hence, if, say, the look of clothing changes owing to the whims of fashion, this is not construed as a quality change that is relevant to prices.

One method of adjusting price changes for changes in quality that is frequently applied in Germany is the CHAIN-LINKING IN OVERLAPPING PERIODS[1] or OVERLAP PRICING[2]. This method involves collecting the prices of the old price representative and of the new one in parallel during at least one period. The price difference between the two models to be observed at a given point in time can then be approximately interpreted as the MARKET EVALUATION OF THE DIFFERENCE IN QUALITY, and a direct assessment of the different characteristics of the two models is made unnecessary.

In technical terms, the price change is quality-adjusted by means of what is known as an ADJUSTMENT OF THE BASE PRICE (price in the base period),[3] rather than by adjusting the price of the new model. The item price index that is included in the computation of the overall index is calculated as a ratio of the current price and of the base price. If price representatives change, without any quality adjustments prices of two different goods would be compared. Hence, an intertemporal comparison of prices that is to be meaningful presupposes the adjustment of either the current price or the base price for the monetary value of the change in quality. The Federal Statistical Office opted for the adjustment of the base price, since by doing so current prices for the contemporary model do not have to be repeatedly corrected in subsequent periods. A one-off calculation of a new notional base price p_B^0 suffices for further measurement of price changes (Table 9). To obtain the new notional base price, the old base price p_A^0 is multiplied by the relative price of the new model in terms of the old model p_B^1/p_A^1. Index figures are then calculated for the new base price as usual.

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1 See, for example, Statistisches Bundesamt (1990), Szenzenstein (1995), Neubauer (1996), Kokoski (1993).

2 See Armknecht/Weyback (1989).

3 See Neubauer (1981).

Table 9: Chain-linking in overlapping periods

	Model A		Model B	
Point in time	Price	Index figure	Price	Index figure
t=0	p_A^0	-	$\left(p_B^0 = p_A^0 \frac{p_B^1}{p_A^1}\right)$	-
t=1	p_A^1	$I_A^1 = 100 * \frac{p_A^1}{p_A^0}$	p_B^1	$\left(I_B^1 = 100 * \frac{p_B^1}{p_B^0} = \frac{p_B^1}{p_A^0}\frac{p_A^1}{p_B^1} = \frac{p_A^1}{p_A^0}\right)$
t=2	-	-	p_B^2	$I_B^2 = 100 * \frac{p_B^2}{p_B^0} = \frac{p_B^2}{p_B^1}\frac{p_A^1}{p_A^0}$

What is, above all, essential to the reliability of this method is that both models are still being sold in similar quantities and at normal prices, so that the price difference approximately reflects the market evaluation of the difference in quality. If only a limited number of the old variant is offered at a CLEARANCE SALES PRICE, however, the price difference included in the adjustment calculation would be too large, which would result in an overstatement of the advance in quality and an UNDERSTATEMENT OF THE TRUE RATE OF PRICE INCREASE.[1] This also holds true if an upward adjustment of prices is linked to the introduction of a new model and if the old model is being sold off at the old price owing to menu costs.[2] If, conversely, the new model is initially still being sold at a low INTRODUCTORY PRICE while the old product is, for the time being, still being sold at the normal price, the price difference would be relatively small compared with the differences in quality, and the total price increase would be overstated.

Thus, the method of chain-linking in overlapping periods reliably provides the correct result only if the market is in long-term equilibrium. This requirement is likely to be typically met in the case of successful models of the same vintage, for which the problem of linking indices does not arise. This will not be the case, however, if there are regular product changes, especially if producers carry them out in a more or less synchronised fashion.[3]

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1 Harhoff/Moch (1997) provide a nice example for this phenomenon.

2 See Kokoski (1993), Reinsdorf/Liegey/Stewart (1996).

3 See Deneffe (1958).

Even if the typical problem of the substitution of a price representative following a change of model is disregarded, this method of chain-linking in overlapping periods is fraught with problems. Admittedly, the instructions for price statisticians state that:

> "If the price statistician notes or learns that a type of good that has hitherto been included in price monitoring is losing its importance in terms of turnover and is likely to continue to do so, he should not wait any longer and, instead, switch to a new type of that good that is as similar to the old one as possible.
>
> The difference in quality between the old good and the new one could hereby be easily equated with the difference in price. Hence, it may be expected that no true increase or decrease in price has occurred."[1]

This is immediately followed by the qualification that price statisticians must in all cases enquire at the reporting unit about the relationship between differences in prices and quality. As a rule, however, the entire price difference is likely to be eliminated for inflation measurement. Even under extremely favourable conditions, however, this method results in the rate of price increase being overstated, since it is ultimately only by virtue of a superior price-performance ratio that a product can squeeze a competing model out of the market.[2] Hence, if the market share of one product increases and that of another decreases, the product whose market share is rising must be superior in the judgement of the consumers; in that case, however, the method of chain-linking in overlapping periods leads to an overstatement of the rate of price increase.[3] Hence, the method of chain-linking in overlapping periods, which at first sight appears to be extremely attractive, supplies reliable results precisely under those conditions where a substitution of price representatives is unnecessary.[4] In most other cases, it will result in the rate of price increase not being recorded accurately.

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1 Statistisches Bundesamt (1990).

2 See Nicholson (1967).

3 See also Lequiller (1997).

4 For that reason, in the United States the method of chain-linking in overlapping periods is now applied solely to the regular rotation of the price representatives which is customary in that country, and not to forced substitution. See also Armknecht (1996).

d) Direct Procedures for Adjusting Prices for Changes in Quality

> "... very frequently, especially in times of moderate price changes, true changes in prices effected by the producer occur only in connection with changes in quality."
> Guckes (1976)

In most cases, price statisticians have no choice but directly to estimate the monetary value of the change in quality. Sometimes this can be comparatively easy, say, if the contents of a package of food are changed only marginally. In that case, a corresponding price is calculated per weight unit or per volume unit. In many other instances, however, it is very difficult to make an accurate assessment of changes in quality.

Owing to the extremely complex problems involved in the quality adjustment of prices, the FEDERAL STATISTICAL OFFICE has therefore drawn a SIMPLIFIED PROCEDURE.[1] This procedure comprises a total of six different rules, the first three of which relate to UNIDIRECTIONAL CHANGES IN QUALITY AND PRICES.

These rules ask the price statistician to dissect mentally the CHANGE IN THE MARKET PRICE Δp into a "TRUE" CHANGE IN PRICES ΔP_r and the MONETARY VALUE ΔP_q OF THE CHANGE IN QUALITY:

(5) $\Delta p = \Delta p_r + \Delta p_q$

These two variables are then compared with one another:

a) "THE TRUE INCREASE (OR DECREASE) IN PRICE CONTAINED IN THE PRICE DIFFERENCE IS GREATER THAN THE IMPROVEMENT (OR DETERIORIORATION) IN QUALITY." In this case, the price change should be calculated on the basis of the price of the new type of good and the price of the forerunner model (DIRECT COMPARISON). The difference in quality is thus disregarded when prices are compared. This procedure leads to the price increase being overstated if there is an advance in quality, and results in the price increase being understated if there is a slackening of quality.

b) THE TRUE INCREASE (OR DECREASE) IN PRICE THAT IS CONTAINED IN THE DIFFERENCE IN PRICE IS ROUGHLY EQUIVALENT TO THE IMPROVEMENT (OR

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1 See Reich/Sonntag/Holub (1977), Neubauer (1981), Statistisches Bundesamt (1990).

DETERIORATION) IN QUALITY". According to the instructions, in that case the base price has to be increased (decreased) by half the difference in price.[1] This is broadly referred to as the method of CHAINING WITH A CORRECTION FACTOR, the latter being generally fixed as 50 % of the price difference. Whether a bias does or does not emerge depends on the actual differences in prices and quality.

c) "THE TRUE INCREASE (OR DECREASE) IN PRICE CONTAINED IN THE DIFFERENCE IN PRICE IS LESS THAN THE IMPROVEMENT (OR DETERIORATION) IN QUALITY". In this case, the base price is adjusted by the full difference in price. This, too, is an instance of the method of CHAINING WITH A CORRECTION FACTOR, with the latter now being generally set at 100 % of the difference in price. Thus, the price index indicates neither an increase nor a decrease in price. This method corresponds to the assumption - which, however, does not apply here - that the difference in price is exactly equal to the value of the difference in quality. If this rule is applied, the rate of price increase will be understated if there is an improvement in quality and overstated if there is a deterioration in quality.

The other three cases concern mainly CHANGES IN QUALITY ACCOMPANIED BY CONTRARY CHANGES IN PRICES. If such combinations occur, they have to be reported to the statistical offices of the reporting municipalities. Generally, however, adjustments of the base price are not carried out; instead, the prices will be chain-linked directly (DIRECT COMPARISON). Three individual cases are distinguished here:

d) QUALITY CHANGE WITHOUT ANY CHANGE IN PRICE (overstatement of price increase if there is an improvement, understatement of price increase if there is a deterioration).

e) IMPROVEMENT IN QUALITY COINCIDING WITH A DECREASE IN PRICE (overstatement of the rate of price increase).

f) DETERIORATION IN QUALITY COINCIDING WITH AN INCREASE IN PRICE (understatement of the rate of price increase).

In Table 10 the instructions of the Federal Statistical Office for adjusting prices for changes in quality, and its implications, are shown according to a different system. From large price increases in the event of improvements in quality to sharp decreases in prices in the event

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1 In times of a sharp increase or decrease in prices, this procedure is problematic insofar as the base price is adjusted by means of the inflated or deflated value of the present period, resulting in the rate of the true price increase or decrease being recorded too low.

of reductions in quality, the entire range of changes in prices and quality is shown in detail. This also fills in the gaps in the Federal Statistical Office's instructions![1]

The question arises as to whether these procedures ensure on average that prices are adequately adjusted for changes in quality. First, I intend to examine whether a general bias is possible. Initially, a MODEL CALCULATION is used to derive the measurement bias given a change in quality, when this is correctly identified and assessed but subsequently eliminated according to the generalising rules of the Federal Statistical Office.

For simplification, this calculation starts from TWO MAJOR ASSUMPTIONS:

- IMPROVEMENTS IN QUALITY occur more frequently than reductions in quality. In modern economies, at least, no proportionate or disproportionately high overall increase in quantity is to be found. With increasing income, for the most part people do not eat more food but food of a higher quality; they do not buy not only an increasing number of cars but also more luxurious and faster cars. Thus, the bias should not be too large if the following considerations initially focus on improvements in quality.
- Prices are typically adjusted when models change - because of menu costs - and remain unchanged until the next change of model.[2] Given one model change per year, the analysis can be confined to ANNUAL RATES OF CHANGE IN PRICES AND IN QUALITY.[3]

Dissecting the price difference between the old and the new model into the true change in price and the monetary value of the advance in quality according to equation (5) is crucial

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1 These gaps concern mainly unidirectional changes in prices and quality, the true rate of price increases, however, having a sign which is different from that of the change in market prices. If, for example, the price of a good increases by DM 10 while its utility value was raised by DM 15, the true rate of the price increase is DM 5. In that case it would make sense to follow rule c) and to adjust the base price by the difference in price.

Another gap relates to rule b). The instructions of the Federal Statistical Office do not specify in detail the range around the monetary value of the improvement in quality to which this rule is to be applied. In Table 11 and in the following model calculations it is assumed that this interval is between one-half and one-and-one-half times the monetary value of the change in the product specification.

2 Using data for the United States, Moulton/Moses (1997) show that a large part of the price changes occur with substitutions of products.

3 The counts of the methods applied for the quality adjustment of prices, which were introduced upon suggestion of Eurostat recently, will probably be able to show whether these assumptions are appropriate for Germany.

Table 10: The instructions for adjusting prices for changes in quality

Case	Change in price	Monetary value of the change in quality	True change in price (compared with the change in quality)	Rule	Adjustment of base price	(Relative) bias
(1)	$\Delta p > 0$	$\Delta p_q > 0$	$\Delta p_r > \frac{1}{2}\Delta p_q$	a)	0	$\frac{(p_b + \Delta p_r + \Delta p_q)/p_b}{(p_b + \Delta p_r)/p_b} - 1 = \frac{\Delta p_q}{p_b + \Delta p_r} > 0$
(2)	$\Delta p > 0$	$\Delta p_q > 0$	$\frac{1}{2}\Delta p_q \leq \Delta p_r \leq \frac{3}{2}\Delta p_q$	b)	$\frac{1}{2}\Delta p$	$\frac{(p_b + \Delta p_r + \Delta p_q)/(p_b + \frac{1}{2}\Delta p)}{(p_b + \Delta p_r)/p_b} - 1 = \frac{\frac{1}{2}(p_b\Delta p_q - p_b\Delta p_r - \Delta p\Delta p_r)}{(p_b + \Delta p_r)(p_b + \frac{1}{2}\Delta p)} \gtrless 0$?
(3)	$\Delta p > 0$	$\Delta p_q > 0$	$0 < \Delta p_r < \frac{1}{2}\Delta p_q$	c)	Δp	$\frac{(p_b + \Delta p_r + \Delta p_q)/(p_b + \Delta p)}{(p_b + \Delta p_r)/p_b} - 1 = \frac{-\Delta p_r}{(p_b + \Delta p_r)} < 0$
(4)	$\Delta p > 0$	$\Delta p_q > 0$	$\Delta p_r \leq 0$	[c)]	Δp	$\frac{(p_b + \Delta p_r + \Delta p_q)/(p_b + \Delta p)}{(p_b + \Delta p_r)/p_b} - 1 = \frac{-\Delta p_r}{(p_b + \Delta p_r)} \geq 0$
(5)	$\Delta p > 0$	$\Delta p_q = 0$	$\Delta p_r > 0$	-	0	$\frac{(p_b + \Delta p_r)/p_b}{(p_b + \Delta p_r)/p_b} - 1 = 0$
(6)	$\Delta p > 0$	$\Delta p_q < 0$	$\Delta p_r > 0$	f)	0	$\frac{(p_b + \Delta p_r + \Delta p_q)/p_b}{(p_b + \Delta p_r)/p_b} - 1 = \frac{\Delta p_q}{p_b + \Delta p_r} < 0$

(7)	$\Delta p = 0$	$\Delta p_q > 0$	$\Delta p_r < 0$	d)	0	$\frac{(p_b + \Delta p_r + \Delta p_q)/p_b}{(p_b + \Delta p_r)/p_b} - 1 = \frac{\Delta p_q}{p_b + \Delta p_r} > 0$
(8)	$\Delta p = 0$	$\Delta p_q = 0$	$\Delta p_r = 0$	-	0	$\frac{(p_b + \Delta p_r)/p_b}{(p_b + \Delta p_r)/p_b} - 1 = 0$
(9)	$\Delta p = 0$	$\Delta p_q < 0$	$\Delta p_r > 0$	d)	0	$\frac{(p_b + \Delta p_r + \Delta p_q)/p_b}{(p_b + \Delta p_r)/p_b} - 1 = \frac{\Delta p_q}{p_b + \Delta p_r} < 0$
(10)	$\Delta p < 0$	$\Delta p_q > 0$	$\Delta p_r < 0$	e)	0	$\frac{(p_b + \Delta p_r + \Delta p_q)/p_b}{(p_b + \Delta p_r)/p_b} - 1 = \frac{\Delta p_q}{p_b + \Delta p_r} > 0$
(11)	$\Delta p < 0$	$\Delta p_q = 0$	$\Delta p_r < 0$	-	0	$\frac{(p_b + \Delta p_r)/p_b}{(p_b + \Delta p_r)/p_b} - 1 = 0$
(12)	$\Delta p < 0$	$\Delta p_q < 0$	$\Delta p_r \geq 0$	[c)]	Δp	$\frac{(p_b + \Delta p_r + \Delta p_q)/(p_b + \Delta p)}{(p_b + \Delta p_r)/p_b} - 1 = \frac{-\Delta p_r}{(p_b + \Delta p_r)} \leq 0$
(13)	$\Delta p < 0$	$\Delta p_q < 0$	$\Delta p_r < 0$ $0 < \lvert\Delta p_r\rvert < \lvert\tfrac{1}{2}\Delta p_q\rvert$	c)	Δp	$\frac{(p_b + \Delta p_r + \Delta p_q)/(p_b + \Delta p)}{(p_b + \Delta p_r)/p_b} - 1 = \frac{-\Delta p_r}{(p_b + \Delta p_r)} > 0$
(14)	$\Delta p < 0$	$\Delta p_q < 0$	$\Delta p_r < 0$ $\lvert\tfrac{1}{2}\Delta p_q\rvert \leq \lvert\Delta p_r\rvert \leq \lvert\tfrac{3}{2}\Delta p_q\rvert$	b)	$\frac{1}{2}\Delta p$	$\frac{(p_b + \Delta p_r + \Delta p_q)/(p_b + \frac{1}{2}\Delta p)}{(p_b + \Delta p_r)/p_b} - 1 = \frac{\frac{1}{2}(p_b\Delta p_q - p_b\Delta p_r - \Delta p\Delta p_r)}{(p_b + \Delta p_r)(p_b + \frac{1}{2}\Delta p)} \gtrless 0$?
(15)	$\Delta p < 0$	$\Delta p_q < 0$	$\Delta p_r < 0$ $\lvert\Delta p_r\rvert > \lvert\tfrac{3}{2}\Delta p_q\rvert$	a)	0	$\frac{(p_b + \Delta p_r + \Delta p_q)/p_b}{(p_b + \Delta p_r)/p_b} - 1 = \frac{\Delta p_q}{p_b + \Delta p_r} < 0$

for the considerations below. At instantaneous rates of change, the following equation is obtained, with ψ symbolising the change in the market price:

(6) $\psi_i = \pi_i + \phi_i$

In this equation, π stands for the true change in prices, ϕ for the growth in quality. For the following notional experiment, the PERCENTAGE CHANGE OF THE GROWTH IN QUALITY is kept constant at 1 % per annum and the TRUE RATE OF PRICE INCREASE is varied from -2 % to +3 % p.a. so that all rules relevant to advance in quality are used.

The detailed procedure is as follows:

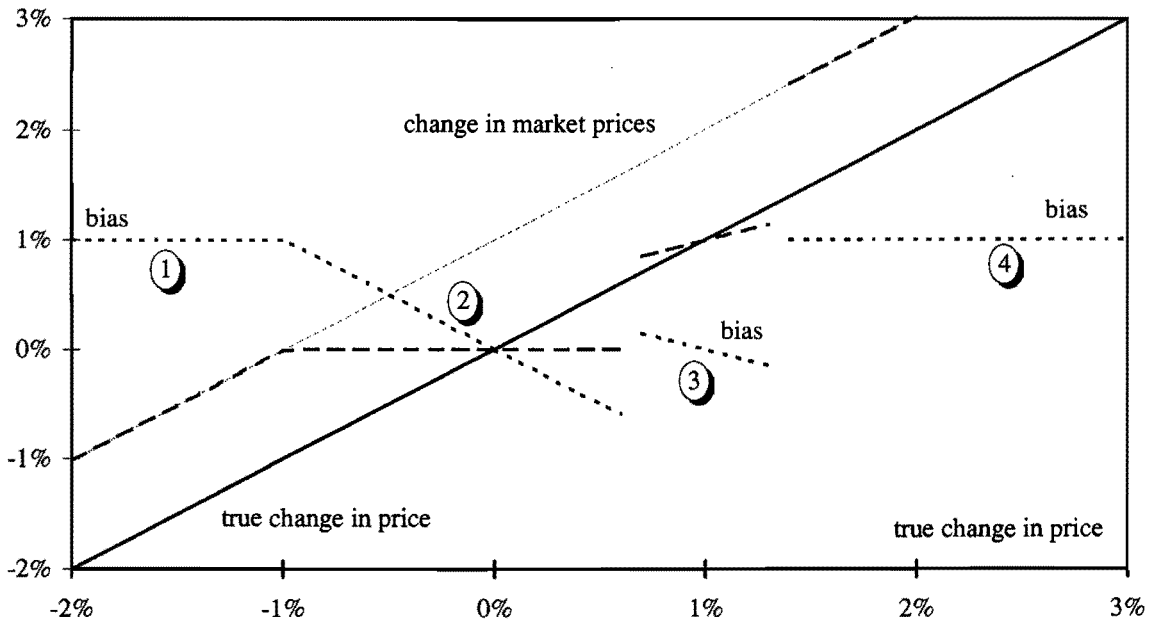
- First, a TRUE RATE OF PRICE INCREASE is assumed.
- The assumed RATE CHANGE OF THE QUALITY yields a RATE OF CHANGE OF THE MARKET PRICE.
- Assuming an absolute price for the base period, the MONETARY VALUE OF THE CHANGE IN QUALITY and the TRUE CHANGE IN PRICE can then be calculated.
- The INSTRUCTIONS OF THE FEDERAL STATISTICAL OFFICE are applied to these data. If required under these instructions, the BASE PRICE IS ADJUSTED.
- Finally, QUALITY-ADJUSTED PRICE INDEX FIGURES are calculated as a ratio of the market prices and the adjusted base prices.
- The quotient of the index figures for the quality-adjusted prices and for the true price change yields an INDEX FIGURE FOR THE BIAS. If the price index that was adjusted for quality according to the methods of the Federal Statistical Office rises faster than would be consistent with the true rate of price increase, the bias is greater than zero.

The results of the model calculation are shown in Chart 4. The bias is a function of the true quality-adjusted rate of price increase. The true change in prices is plotted on the horizontal axis; plotted on the vertical axis are:

- the TRUE CHANGE IN PRICE (dark continuous line),
- the CHANGE IN THE MARKET PRICE (light dotted line),
- the CHANGE IN THE QUALITY-ADJUSTED PRICE INDEX (broken line), and
- the BIAS (dotted line),

all in relation to the TRUE RATE OF INFLATION, the graph of which therefore corresponds exactly to the line of the diagonal.

Chart 4: The quality change bias for one good as a function of the true change in prices (at 1 % growth in quality)



If the BIAS IS ZERO, the line indicating the change in the quality-adjusted price index is congruent with the diagonal; if the recorded inflation rate is congruent with the line indicating the change in market prices, a maximum bias is obtained: the change in quality is not included at all. Depending on the combination of the changes in price and quality, four of the above-mentioned rules are applied for calculating the price index:

- In range ① the quality rises and the market price falls (see case 10 in Table 10). Therefore RULE e is applied: the new (lower) price is adopted unchanged, and no adjustment is made for the improvement in quality. The bias reaches its maximum size.
- In range ②, the true change in prices is initially still less than zero, whereas the market price is already increasing (see case 4 in Table 10). Even if the rules of the Federal Statistical Office are unclear on this point, it is nevertheless assumed that RULE c is to be applied here and hence that the base price is adjusted by the change in the market price. As ② progresses, the true change in price finally becomes positive, but it still remains significantly lower than the monetary value of the improvement in quality (case 3 in Table 10). Hence, RULE c applies in the strict sense here. Starting from its maximum value, the bias therefore declines in line with the true rate of inflation and eventually even becomes negative.

- In range ③, the true increase in price is of a similar order to that of the monetary value of the change in quality (case 2 in Table 10). Hence, RULE b must be applied, according to which one-half of the difference in prices is ascribed to the improvement in quality in a generalised manner. Starting from a positive value, the bias declines in line with the rate of inflation and is eventually becoming negative.
- Finally, in range ④, the true increase in prices is markedly greater than the monetary equivalent of the advance in quality (case 1 in Table 10). RULE a is effective here: the new (higher) price is adopted unchanged. Again, the bias reaches its maximum level.

On the whole, with increasing inflation, the bias - assuming approximately one percentage point given a fall in price - would initially drop down to a negative value and reassume the maximum value as the rate of price increase continues to rise. In the range of a medium rate of price increase, the bias declines section-wise in line with the rate of inflation; however, it increases again in stages in the interim.

Thus, this theoretical examination of the generalising rules of the Federal Statistical Office yields the following HYPOTHESES ON THE QUALITY CHANGE BIAS FOR INDIVIDUAL GOODS:

- For changes of prices in a small range around the rate of the product-specific advance in quality, the bias should be small (since, according to rule b and c, an approximately adequate requirement is applied).
- In the case of small or large increases in prices that are more remote from the improvement in quality, the bias will be large and positive.

This result must be modified for larger changes of prices. Theoretical models and empirical studies support the assumption that the FREQUENCY OF PRICE ADJUSTMENTS increases in line with the rate of inflation,[1] shortening the intervals between price adjustments. Then the assumption of no more than one price adjustment per year, synchronised to coincide with a change of the product, might then no longer be appropriate. Furthermore, in an increasing number of cases price adjustments might occur independently of changes in quality, even if producers would presumably still try to disguise true increases in prices behind improvements in quality. In the case of more than one price adjustment per year, however, the price increases occurring on the occasion of model changes might again approximate more closely to an advance in quality. In that case, the generalising rules of the Federal

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1 See, for example, Cecchetti (1986) and Kashyap (1995).

Statistical Office could yield better results. On the other hand, producers will endeavour to continue to justify increases in prices on the grounds of minor improvements in quality, so that the theoretical possibility of a smaller bias in the case of higher percentage changes of prices may not be of such great importance as assumed.

3. Alternative Calculations of Quality-adjusted Price Changes

> "If a poll were taken of professional economists and statisticians, in all probability they would designate (and by a wide majority) the failure of the price indexes to take full account of quality changes as the most important defect in these indexes. And by almost as large a majority, they would believe that this failure introduces a systematic upward bias in the price indexes - that quality changes have on average been quality improvements. "
> Price Statistics Review Committee (1961)

a) Preconceptions and Earlier Studies

There is a widespread preconception among economists that the price indices published by statistical offices overstate inflation because of changes in quality not being adequately taken into account. This prejudice is principally based on two assumptions:[1]

- The statistical offices make no allowance for changes in quality or, if they do, only to a minor extent.
- In a growing economy, the quality of the goods and services is continually improving.

By contrast, price statisticians firstly point to a number of deteriorations in quality that are likely not to be taken into account in inflation measurement at all, or, if they are, scarcely to an adequate extent. For example, in contrast to what used to be the case, delays in air traffic are quite common nowadays;[2] letter boxes are now emptied no more than five times a week, apartments deteriorate with use over time. Secondly, the statistical offices use a variety of methods to adjust price changes for advances in quality; if errors or inaccuracies occur when these adjustments are made, the bias could lead either to an understatement or an overstatement of the price increase. The question of whether an inadequate allowance for changes in quality results in the recorded overall rate of inflation being too high must be answered by individual studies. These should be based both on an analysis of the procedures applied by the statistical offices and on alternative calculations. This much is certain: the controversy between economists and statisticians cannot be resolved at the abstract level.

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[1] See Triplett (1971)

[2] However, people like to tend to ignore the fact that the density of the schedules in air traffic has increased.

In the United States there are a large number of studies which make a detailed examination of the methods and results of price measurement for individual goods. An outstanding example is Gordon's monumental study on the US Producer Price Index.[1] Almost all of these studies conclude that the official price statistics systematically underestimate quality changes and therefore overestimate the true rate of price increase. Although experts in Germany, too, are aware that the quality adjustment of price series harbours enormous problems, only a small number of specific case studies on this have been undertaken so far. The author knows of only three studies: A dissertation written at the University of Frankfurt on price trends in refrigerators,[2] a study by the Federal Statistical Office on price trends in computers,[3] and a study by the ZEW on the possibilities of price measurement with regard to database software[4] A considerable amount of work thus still has to be done on this in Germany.

b) Data Sources and Data Problems

Ideally, alternative calculations of quality-adjusted price indices should draw on data collected for the official price statistics. By doing so, it would be possible to examine in detail the questions, firstly, of whether the prescribed methods are being applied correctly, and, secondly whether these methods yield meaningful results. However, this would suppose the availability of prices for precisely specified products in the consumer price statistics. As described above, however, such data are not available (see p. 40f). Therefore, data that have been collected for different purposes have to be relied on.[5] Such data records must, on the one hand, contain prices, and, on the other, product specifications, which are as detailed as possible.

These requirements are met most closely by MAIL-ORDER CATALOGUES and TECHNICAL JOURNALS which regularly shed light on markets for specific products. Gordon (1990), for example, drew on this kind of data for his study. Another possible source are MARKET RESEARCH INSTITUTIONS that are commissioned by producers to assess

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1 See Gordon (1990)

2 See Riegel (1975).

3 Gnoss/Minding (1990) and Gnoss (1995).

4 Moch (1995) and Harhoff/Moch (1997).

5 This must be taken into account later on in the interpretation of the results. See Triplett (1971) and, above all, Triplett/McDonald (1977).

the market position of their products on a regular basis. However, the data obtained by those institutions are both very expensive and, in most cases, strictly confidential, since they permit a detailed insight into the marketing strategy and the operational success of individual enterprises. The great advantage of mail-order catalogues over technical journals is that, twice per year, they list the prices of a large number of product variants, allowing semi-annual indices to be calculated. However, mail-order catalogues capture only a very specific segment of the market. By contrast, technical journals cover various segments of a market quite accurately - albeit at irregular intervals - producing an overall picture of the trends in prices and in quality over longer periods of time. Furthermore, the product descriptions in technical journals are often more detailed than those in mail-order catalogues.

As no more than a limited amount of time was available for this study, only a restricted number of goods could be taken into consideration. Finally, price trends for WASHING MACHINES, REFRIGERATORS, and FREEZERS were analysed in detail. One reason for this selection was that these electrical appliances have objectifiable and, at the same time, comparatively easily observable quality attributes and that these should play a major role in the buying decision. Furthermore, in comparison with other products, such as automobiles, there are no more than fairly minor differences in their design; these are, more-over, unlikely to be a crucial factor in the buying decision. Finally, these are goods that are not subject to such a rapid advance in quality as are, say, computers. The fact that statistical offices find it hard to make adequate quality adjustments for computer prices using the traditional methods is understandable. By contrast, quality changes in refrigerators and washing machines are likely to be more typical of the majority of products.

The monthly magazine TEST, published by STIFTUNG WARENTEST[1], regularly reports about prices and quality characteristics of selected washing machines, refrigerators and freezers. The prices are usually collected by a market research institute in a representative sample of outlets. The median of prices is quoted for models that are traded on a decentralised basis; in exceptional cases, the mean of prices or the price stated by the manufacturer is listed instead. The catalogue price is quoted for mail-order appliances. The tests of the goods also contain quite detailed descriptions of the technical attributes, some of which are examined in the tests. The marketability of the individual models is unknown; however, according to the information provided by Stiftung Warentest, the products' market importance is taken into account when selecting the models for the tests. Normally, products be-

[1] Stiftung Warentest is a non-profit-making organisation which was founded in 1964 by the Federal Government. Its most important task is to conduct tests of products and services.

longing to a specific market segment (e.g. medium price range or luxury models) are combined in one test so that different layers of the market are scrutinised alternately. Issues of the magazine TEST from early 1980 to mid-1997 were exploited for the present study.[1]

c) Hedonic Quality Adjustments of Price Changes

> "What the hedonic approach attempted was to provide a tool for estimating "missing" prices, prices of particular bundles not observed in the original or later periods. ... To accomplish even such limited goals, one requires much prior information on the commodity in question (econometrics is not a very good tool when wielded blindly), lots of good data, and a detailed analysis of the robustness of one's conclusions relative to the many possible alternative specifications of the model. "
> Ohta/Griliches (1975)

HEDONIC PICE EQUATIONS have proved to be a very promising method for calculating price indices that are adjusted for changes in quality, but not so much for monthly indices as for calculations over longer time spans.[2] They start with the idea that various versions of a heterogeneous good (=models) can be represented as differing combinations of individual, well-defined (homogeneous) product characteristics. Price differences prevailing in competitive markets at a given point in time can thus be explained by the models' characteristics. Such cross-section information can also be used for a intertemporal comparison of prices.

A large number of studies drawing on the hedonic technique have been prepared especially in the United States. In particular, the price trends of automobiles[3], electric household appliances[4], computers[5] and pharmaceuticals[6], as well as interregional differences in the cost

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1 As a supplement, an analysis of department store catalogues would undoubtedly also have been useful in order to subject the results to a further test with an alternative data record. However, owing to the limited amount of time available, this was not possible and must be left for future studies.

2 For an overview of the possibilities and problems of hedonic price studies, see for example Griliches (1971), Pollak (1983), Triplett (1987), Triplett (1990), and Gordon (1990).

3 Early studies on automobile prices were undertaken by Court (1939) and Griliches (1961).

4 See for example Dhrymes (1971) and Gordon (1990).

5 See especially Chow (1967), Cole et al. (1986). For an overview, see Triplett (1989).

6 See, for example, Berndt/Cockburn/Griliches (1996).

of housing[1] have been investigated. For the compilation of official price indices in the United States, hedonic methods are now being applied, *inter alia*, to clothing,[2] new multi-family housing,[3] and computers[4]. So far, few studies of this kind have been carried out for Europe. For example, studies on the quality-adjusted price trends of automobiles have been made for the United Kingdom[5] and for Portugal.[6] Song (1994) estimated hedonic price equations for automobiles and compact cameras in Finland. In addition, the three studies for Germany mentioned above belong to this category, too (see p. 55). In France, the hedonic method is applied to the calculation of price indices for microprocessors and printers.[7] Finally, the Bank of Japan has published studies on the prices of computers[8] and cars.[9] For applications of the hedonic method in the field of services, see Armknecht/Ginsberg (1992).

The most significant problems arising in the estimation of hedonic price equations relate to the functional form of the hedonic price equation and the selection of the explanatory variables. The discussion below is not intended to be an exhaustive treatment of the theoretical and econometric problems inherent in the hedonic method but rather as a pragmatic statement of the methods applied, which makes no apologies for adopting an eclectic approach.

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1 See, for example, Moulton (1995).

2 See Liegey (1993). More recent studies have shown, however, that on average there were hardly any major deviations between the old quality-adjusted price indices and the new indices that were obtained by means of hedonic estimates. See Liegey (1994).

3 See de Leeuw (1993).

4 See Cartwright (1986).

5 See Cowling/Cubbin (1972), Blow/Crawford (1998).

6 See Santos/Coimbra (1995).

7 See Moreau (1996).

8 See Shiratsuka (1995a).

9 See Shiratsuka (1995b).

ca) On the Functional Form of the Hedonic Price Equations

In the literature, the opinion prevailed for a long time that economic theory imposed scarcely any restrictions on the functional form of hedonic price equations.[1] Although a number of theoretical studies on this issue were published in the seventies[2], in the eyes of practitioners they did little to shed light on this matter, especially as the practical conclusions differed depending on the underlying model being used. Therefore, it appeared prudent to many users to decide which functional form would be adequate solely on statistical criteria.[3] Those studies, most of which were written quite a while ago, found that the semi-logarithmic and the log-linear forms proved to be more useful than the linear form.

In a more recent study, Arguea/Hsiao (1993) examined this issue once again in greater detail.[4] Their discussion of the specification problem arising in hedonic estimates is principally based on GORMAN´s (1956/1980) and LANCASTER´S (1966) APPROACH TO CONSUMER THEORY.[5] In this model, it is not goods but their characteristics which are used as arguments of households' utility functions. Gorman and Lancaster now showed that, under certain circumstances, in perfect competitive markets the price of a model can be represented as a linear combination of its characteristics. Therefore, the appropriate form of the hedonic price function is linear, too.[6] Hence, the main question concerns the size of market and the degree to which the products are differentiated. If there is a continuum of products, the market is competitive, and the appropriate specification of the hedonic price equations is linear.[7] On the other hand, if the market is segmented and not perfectly competitive, non-linear specifications might become more appropriate.

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1 See for example, Halvorsen/Pollakowski (1981), Triplett (1987).

2 See Muellbauer (1974), Muellbauer (1975), Lucas (1975).

3 See, for example, Cropper/Deck/McConnell (1988).

4 See also Blow/Crawford (1998) for a deeper discussion of these subjects.

5 This is a highly simplified representation of the conclusions drawn from these models for quality measurement. For details, see, for example, Lancaster (1977).

6 See also Lucas (1975).

7 In their study, Arguea and Hsiao (1995) themselves conclude after many different series of tests that even the US market for automobiles was sufficiently competitive in the period between 1969 and 1986 to allow car prices to be described by a linear hedonic function. This result, however, tends to contradict older studies - for example by Ohta/Griliches (1975) - according to which non-linear specifications proved to be more useful empirically than the simple linear form.

Feenstra (1995), however, obtained similar results in a MODEL WITH MONOPOLISTIC COMPETITION. In a well specified hedonic price function the mark-up of the prices over marginal costs would have to be included as an explanatory variable. As information on the mark-up is difficult to obtain, this variable will normally not be available. In that case, the estimated parameters for the quality variables may be biased. As Feenstra (1995) showed making plausible assumptions, the linear model will nevertheless yield unbiased estimates for assessing the characteristics, whereas the log-linear version systematically produces values which are too high for the implicit assessment of the quality variables. Given increasing quality, a hedonic price index would then be biased downwards.

The following hedonic studies deal exclusively with electrical household appliances. Although the number of their product variants is smaller than that of automobiles, the preferences of households are likely to be more similar to each other in this case, so that the market might be less separated than in the case of automobiles. In tests, however, none of the functional forms - linear, semi-logarithmic, log-linear - proved to be clearly superior. The implicit quality-adjusted percentage price increases, too, differ only slightly. In view of these results, the question of the correct functional form seems, if anything, to be a problem to which too much importance is attached.

The starting point of the estimates is thus a linear specification of the hedonic equation which is complemented by semi-logarithmic or log-linear variants.

For the linear form, it is assumed that the price of a model i can be represented as a linear combination of the characteristics x_{ji}:

$$(7) \qquad P_i = \sum_j c_j x_{ji}$$

The weights c_j - like the price of the good - have the dimension [DM/unit]. They can be construed as implicit prices p_j of the characteristics j:

$$(8) \qquad P_i = \sum_j p_j x_{ji}$$

Inflation measurement, however, is less concerned with the implicit prices of the product characteristics than with the average rate of quality-adjusted price change between different periods. Therefore, a price level for a given category of goods is to be calculated as the price of a representative (average) combination of characteristics (analogously to the price level in an economy, which is calculated as the price of a representative basket of goods). A quality-adjusted price index covering t periods is then obtained as a quotient of the ex-

penditure on a certain combination of characteristics, which are valued for the first period at the implicit prices prevailing in the first period, and for the period t at the implicit prices prevailing in the period t, etc.

If the combination of the characteristics x_j is representative for the base period, a Laspeyres index is obtained; if the weights are taken from the period t, a Paasche index will be the result. Similarly, further index forms (Fisher, Törnqvist, etc.) can be calculated.[1] A separate estimate of hedonic price equations for individual periods and the explicit calculation of price indices should be the preferred method if a sufficiently high number of findings for both prices and quality are available.[2] Owing to the lack of data, however, information from two or more periods is generally pooled in one estimate. Normally, this will not help to make up for the lack of observations if the second sample is to be used to estimate a second set of implicit prices for the point in time t. Additional simplifying assumptions on the relationships between the parameters are necessary.

In the following section it is assumed that the relative prices of the characteristics remain constant. This may be an appropriate simplification especially if the surrounding circumstances do not change too dramatically. In addition, the rates of price changes for the product characteristics, and thus also the quality-adjusted price change for a specific product should be constant over time.

The equation for the price of a given good in a sample that has been pooled over several periods can then be expressed as follows:[3]

$$(9) \qquad P_i^t = e^{\pi t} \sum_j p_j^0 x_{ij}$$

or

$$(10) \qquad \ln P_i = \pi t + \ln \sum_j p_j^0 x_{ij}$$

In a set of observations made at several points in time, the DATING OF A PRODUCT - in addition to the product features - is thus a further potentially price-determining characteristic.

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1 See Cowling/Cubbin (1972).

2 Gnoss/Minding (1990) adopted this method in a study on trends in computer prices in Germany.

3 See also, in a similar form, Dhrymes (1971).

In the estimates, the (variable) time interval between the samples is measured in months. The (steady) monthly rate of inflation π is converted into an AVERAGE ANNUAL RATE OF INFLATION:

$$(11) \qquad 100 * \left(e^{12\pi} - 1\right) = 100 * \left(\frac{P^{12}}{P} - 1\right)$$

Thus, an average quality-adjusted rate of inflation is obtained. This can be compared with the average change of the corresponding item price index in the Consumer Price Index. The gap between these two variables would then be a measure of the average quality change bias.

This information will be sufficient if statements about the average bias over longer time spans are of primary interest. However, it is probable that the bias is not constant but varies with the rate of inflation (see p. 52 ff.). As the period under review from 1980 onwards covers phases of stable prices but also of moderate price increases, a more subtly differentiated approach is therefore advisable.

Two options are available here:

- Substitution of the price trend by a polynomial of the n-th degree, or
- using time dummies for the individual periods.

With a POLYNOMINAL OF THE N-TH DEGREE:

$$(12) \qquad \ln P_i = \sum_{k=1}^{n} c_k t^k + \ln \sum_j p_j^0 x_{ij}$$

different price trends can be flexibly approximated.[1] However, the rates of inflation calculated for the fringes of the observation period should not be given too much weight. The time-dependent (monthly) quality-adjusted rate of inflation π_t, is calculated on the basis of the polynomial through differentiation by time:

$$(13) \qquad \pi_t = \frac{\partial\left(\sum_{k=1}^{n} c_k t^k + \ln \sum_j p_j^0 x_{ij}\right)}{\partial t} = \sum_{k=1}^{n} k c_k t^{k-1}$$

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[1] This procedure was also followed by Oliner (1993).

The TIME DUMMY METHOD is more common than the approach using a polynomial. Instead of the continuous time variable, time dummies representing the individual periods are used:

$$(14) \qquad \ln P_i = \sum_k \pi_k T_k + \ln \sum_j p_j^0 x_{ij}$$

with $T_k=1$ in period k and $T_k=0$ for all other periods.

Here the quality-adjusted rate of inflation π_k indicates the gap between the price level of the base sample and the sample k. This corresponds to the cumulative rate of price increase between 0 and k. Accordingly, the inflation rate π_k refers to the time span between the base period and k.

The (implicit) average annual rate of inflation for the time span between 0 and k is calculated as:

$$(15) \qquad 100 * \left(e^{\frac{12}{t_k}\pi_k} - 1 \right) = 100 * \left(\frac{P^{12}}{P} - 1 \right)$$

The (implicit) annual rate of inflation between the periods k_1 and k_2 can likewise be calculated on the basis of the cumulative rate of price increase observed between 0 and k_1 and 0 and k_2, respectively:

$$(16) \qquad 100 * \left(e^{\frac{12}{t_{k2}-t_{k1}}(\pi_{k2}-\pi_{k1})} - 1 \right) = 100 * \left(\frac{P^{12}}{P} - 1 \right)$$

cb) Selection of the explanatory variables

As a rule, products differ in terms of more than one characteristic. Strictly speaking, even two issues of the same model will never be completely identical. Thus, the number of the combination of characteristics will regularly be greater than the number of models (and of prices). The hedonic approach, however, makes sense only if the number of the combinations of characteristics that are independent in linear terms does not exceed the number of prices; otherwise, the implicit prices of the characteristics cannot be identified. Hence, it is essential to make a selection among the set of characteristics.

The product descriptions that are available for the information of customers are normally confined to characteristics that are potentially relevant to price formation. The characteristics which are most likely to be considered in the product tests are those which the testers know from experience to be the principal factor in the buying decision. In some cases, the scope of the product descriptions changes during the period considered in this study. Hence, only characteristics that are consistently mentioned over a longer period are eligible for use in longer-term studies. From the multitude of technical characteristics, those that are objectifiable and for which it can generally be assumed that consumers share the same opinion of the quality of the products were selected for the estimates. Hence, in principle, only those characteristics were used that can be obtained from the product descriptions and be measured without too much time and expense. Furthermore, only ECONOMICALLY RELEVANT CHARACTERISTICS were employed. For example, the weight of a refrigerator is of no direct use to the consumers and should therefore not be included in a hedonic estimate.[1] Lastly, quality characteristics were taken into consideration in the final estimate only if they yielded an economically meaningful explanatory value.

The following product characteristics that potentially determine price formation entailed particular problems:

- PRODUCT CHARACTERISTICS THAT CAN ONLY BE PRODUCED WITH AN ADDITIONAL INPUT OF RESSOURCES BUT ON AVERAGE DO NOT TEND TO BE OF ANY DIRECT INDIVIDUAL USE: Usually such product characteristics are the RESULT OF REGULATIONS,[2] such as the removal of CFCs from refrigerators. The question arises of whether such quality changes ought to be taken into account in price measurement. It appears scarcely possible to give a general answer to this. Due to the ban on CFCs the cost of living increases, at least temporarily, for the individual consumer; therefore, a price index that does not include this type of quality change should be used to deflate private incomes. On the other hand, an increase in prices caused by discarding CFCs indicates a higher consumption of resources in the production of the refrigerators rather than an increase in inflation. The Federal Statistical Office thus takes quality improvements due to public regulations into account if they are embodied in the goods under consideration. On the other hand, however, it is not the case that, say, the price for electricity is adjusted if improved dust filters for power stations are prescribed by law.
- DUMMIES FOR PRODUCER AND RETAILER BRANDS: On the one hand, statistically relevant brand dummies might indicate that markets are not perfectly competitive and that the indi-

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1 See Triplett (1986).

2 See Griliches (1971), Triplett (1986).

vidual enterprises have varying degrees of market power.[1] On the other hand, it is also possible that brand names signal hidden product characteristics to consumers, such as a longer useful life or a reduced need for repairs, once manufacturers have gained a corresponding reputation. The additional price to be paid for certain brand names would then be a remuneration for the greater durability and quality of the machines concerned. However, it makes little sense to insert dummies for all brand names in hedonic price equations. Therefore, the following method was applied when considering BRAND DUMMIES: First, the frequency of the brands and their distribution over the product tests were established. Dummies were tested only for those brands that featured regularly over the entire period. Subsequently, all brand dummies that were not statistically significant at a 10 %-level were discarded. Accordingly, the use of brand dummies is restricted to the leading brands in Germany.

- ASSESSMENT OF THE MODELS BY STIFTUNG WARENTEST: The ratings by Stiftung Warentest proved to be highly significant in the first estimates, albeit at the expense of other explanatory variables. Nevertheless, several points argue against including the Stiftung Warentest's assessment in the hedonic price equations,[2] the main reason being that the average rating did not systemically change during the period observed, although product quality improved dramatically. This seems to indicate that the underlying yardstick varies with time and is geared to the average performance level during a given period. That means, however, that it is no longer suitable for a longer-term comparison of the products.

- MARKET SHARES OF INDIVIDUAL MODELS: Admittedly, market shares of a product are not a product characteristic in themselves, and should therefore not be included in a hedonic price equation. However, a model deserves to be included in a hedonic price equation only if it has been accepted by the consumers.[3] In being restricted to sufficiently large market shares, the estimate is likely to focus mainly on the core of the quality range. Although Stiftung Warentest does not state any market shares, as a rule it only takes into account models possessing a certain market importance. Stiftung Warentest acquires the appliances that are used for the tests approximately one year prior to the publication of its results, the prices, however, are not collected until almost six months before that date - a fact which proves to be extremely useful for our purposes. No prices are given for products that proved to be unsuccessful and had to be withdrawn from the market in the interim; for that reason, they were not included in the hedonic estimate. Furthermore, during the collection of prices the Stiftung Warentest gathers information on model changes or substitutions that have taken place in the meantime or are about to occur. This information, too, was systematically analysed and partially included in the estimates.

- OPERATING COSTS OF CAPITAL GOODS: The total costs for the use of capital goods, such as washing machines, is made up of the purchase price and the discounted operating costs. If two models differ only in respect of their consumption of resources, the difference in price between the two models should not be greater than the cumulative discounted operating expen-

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1 See Ohta/Griliches (1975) on this issue.

2 See also Nerlove(1995), and Combris/Lecocq/Visser (1997) on this issue.

3 See Griliches (1971).

diture. If consumers are fully informed, appliances that are both expensive to buy and also involve high operating costs cannot survive in the market.

The assessment of models with a differing consumption of resources principally depends on the operating expenditure.[1] The higher the resource prices are, the lower the relative price of the less efficient models must be in a market that is in equilibrium. If consumption of resources declines steadily, the advance in quality will be all the higher and the quality-adjusted rise in the price of the capital good concerned will be all the lower, the higher the price component contained in the operating costs is set. If the resource prices rise steadily, the advance in quality will be smaller and the quality-adjusted increase in prices will be higher if an assessment is made at the prices prevailing at the beginning of the observation period (given low resource prices) than if an assessment is made at the prices prevailing at the end of the period under observation.

A satisfying solution to this problem can be found in the HOUSEHOLD PRODUCTION THEORY. In line with this theory, the focus would no longer be on the quality-adjusted price trends of washing-machines but on the change in the costs of washing[2], p_{WM} being the pro rata price of a washing machine per period, p_E the price of the electricity consumed, p_W the price of the water needed and x_{WM}, x_E and x_W representing the respective quantities consumed. The washing machines of the two periods 0 and t are to differ only in respect to their consumption of resources. An ideal price index for the change in the cost of washing would then be:[3]

$$(17) \qquad P_C^{t,0} = \frac{p_{WM}^t x_{WM}^t + p_W^t x_W^t + p_E^t x_E^t}{p_{WM}^0 x_{WM}^0 + p_W^0 x_W^0 + p_E^0 x_E^0}$$

For such an exact price index, a large amount of detailed information would be necessary, which is not available. Stopgap solutions are therefore called for. If the consumption of resources is regarded as another product characteristic in the hedonic estimates, an average assessment is taken into account calculating quality-adjusted price changes. This is consistent with the assumption of constant relative prices. However, prices for water and sewage have risen extremely sharply over the past few years, so that the assumption of constant relative prices seems to be too dramatic a simplification.

This problem can be reduced to some extent by splitting the entire pooled sample into small parts which comprise only two neighbouring tests and applying the time dummy method. The coefficient of the consumption of resources should then change from one estimate to the next in line with the price trend. On the other hand, the resource prices could be directly included in the estimate, which should result in a better adjustment overall, since the assessment of the models in a given period is dependent on the prices of the resources. Here the problem arises that not only the present prices but also the price trend expected for the entire useful life of the

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1 See Berndt (1983).

2 Nordhaus (1997) conducted a study of this kind on the trends in the costs of lighting; he showed that conventional methods of adjusting prices of lighting articles for quality changes dramatically overstate the rate of price increases for lighting.

3 See Gordon (1990).

appliances are relevant. If, for example, the resource prices are expected to rise as sharply as they did in the past, an assessment at present prices would result in an understatement of the superiority of energy-saving models.

The problem of the MULTI-COLLINEARITY, which arises frequently in hedonic price estimates, is closely linked to the selection of the variables: models of higher quality are typically superior in all respects to models from a lower market segment; newer models are typically superior in all respects to old models.[1] This results in estimates that have a high explanatory value but also frequently insignificant and unstable parameters.[2] Generally speaking, problems of multi-collinearity can be considerably reduced by combining more than one period and different market segments into one sample.[3] This holds true particularly if advantageous product characteristics gradually spread downward from the upper segments of the market. For example, for a long time air-conditioning was to be found only in luxury cars; nowadays, it is often a standard accessory in medium-range cars. Electronic window openers are another example. On the other hand, consumers are more likely to have similar preferences in homogeneous sub-markets. In this case, the simple linear form of estimates is appropriate, and the results can be interpreted in a meaningful manner. Owing to the greater homogeneity of the products, however, there are then fewer variations in the product characteristics, so that combining the data, at least over a longer period, is often unavoidable. If the market is not represented in its entirety, the number of explanatory parameters must be kept small in many cases on account of the multi-collinearity problems and the small number of observations. Owing to the problem of missing variables, this might result in biased estimates.[4] Because of the various trade-offs it is therefore not possible to avoid data mining.

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1 See Gordon (1990).

2 This is illustrated in dramatic fashion by the study undertaken by Arguea/Hsiao (1993) on the US automobile market, in which all the initial estimates exhibit a $R^2 > 0.9$, the parameters, however, not being statistically significant to be above zero.

3 For the advantages and disadvantages of doing so, see also Muellbauer (1974)..

4 However, on the basis of Monte Carlo simulations, Cropper/Deck/McConnell (1988) show that a linear model proves to be more useful in the event of misspecifications than semi-logarithmic and log-linear methods or the majority of the other complex approaches.

cc) Structure of the Estimates, further Problems

The following case studies on the quality-adjusted price trends of washing machines, refrigerators and freezers are structured as follows:

- First, the TREND OF THE UNADJUSTED AVERAGE PRICES from the consumer price statistics is compared with the MOVEMENT OF THE QUALITY-ADJUSTED ITEM PRICE INDICES from the Consumer Price Index. This comparison allows preliminary conclusions to be drawn as to the validity of the hypothesis that more extensive quality adjustments are made at moderately rising prices than at stagnating or falling prices.
- In a second step, an attempt is then made to determine the EXTENT OF THE AVERAGE MEASURMENT BIAS. Initially an average percentage change of the index figure obtained from the official price statistics is estimated for this purpose.[1] The product tests are then combined into two samples for each product group. The first sample, which is larger, contains all tests and updates published from 1980 onwards, irrespective of any special features in the measurement of prices and quality. The second group contains only those appliances which approximate to the Federal Statistical Office's product specifications. Furthermore, test updates and tests not including price surveys at the retailers are disregarded. The first sample is intended to capture the market as a whole, the second one to examine the price trends of a relatively homogeneous group of products. Hedonic estimates in linear,[2] semi-logarithmic,[3] and log-linear forms[4] are presented for both samples, both with and without brand dummies.

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1 In these estimates, exclusive use was made of the package Econometric Views (Version 2.0, Quantitative Micro Software, Irvine, California).

2 The linear model has been estimated with non-linear least squares. The prices here are a linear combination of the characteristics:

$$p = \sum_i c_i x_i$$

If, however, several samples are combined and unchanged relative prices are assumed, there results a non-linear relationship between the logarithmic prices and the product characteristics:

$$p = e^{c_t t} \sum_i c_i x_i \qquad \text{or} \qquad \ln(p) = c_t t + \ln \sum_i c_i x_i \,,$$

is obtained.

3 $$\ln(p) = c_t t + \sum_i c_i x_i \,.$$

4 $$\ln(p) = c_t t + \sum_i c_i \ln(x_i) \,.$$

- In order to trace the TIME-DEPENDENT RATES OF INFLATION AND MEASUREMENT BIASES, the linear time variable is subsequently replaced by a polynomial for the entire sample. In the homogeneous sub-samples, however, the time-dummy method has been applied.[1] This would make little sense for the overall sample if, for instance, two related samples were to be formed by simple front-loading washing-machines, and high quality top-loading washing-machines, respectively. As it is not possible to differentiate simultaneously between the additional price for top-loaders and the time interval, the coefficient for the time dummy would not only indicate the true rate of price increase between the two periods observed but also include the additional price for top-loaders.[2]

Sometimes the following problems arose in the estimates:

- HETEROSCEDASICITY: The residues have a systematic relationship with explanatory variables.[3] Accordingly, the standard errors, and thus also the t-values, are biased. Therefore, t-values that were corrected according to White are shown in the results tables.
- SUB-SAMPLES OF VARYINFG SIZES: Large sub-samples might have a distorting impact on the overall result if their composition deviates from that of the other samples,[4] or if they were, say, to exhibit a different trend in prices. Control estimates have shown, however, that these deviations are insignificant.
- Least square estimates of a variable π are not unbiased estimates of e^{π}. Therefore, in the calculation of the quality-adjusted rate of price increase, a correction by a one-half squared standard error would really need to be performed.[5] A typical order of magnitude for π would be 2/100; if the standard error were 1/100, the correction would be 5/100000. Given the insignificant scale of this correction with statistically significant parameters, the correction was omitted.

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1 These estimates will not be shown in the following case studies. See the German version of the discussion paper.

2 For a detailed account of this issue, see Griliches (1971).

3 One cause of heteroscedasticity might be the use of average prices in the case of lacking market shares. See Berndt (1991).

4 See Griliches (1971).

5 See Triplett (1989), with reference to Goldberger (1968).

d) Case Study No. 2: Quality-adjusted Price Changes of Washing Machines

As with the majority of other goods, the specification of washing machines in the German Consumer Price Index is not very narrowly defined (see Table 11). Since 1980, the product specification has been altered, marginally, only once (in 1992) and, if anything, its scope was broadened. The specification includes TOP-LOADERS, in addition to normal FRONT-LOADERS. However, there are much greater differences in the external dimensions of top-loaders. Therefore, there is much to indicate, firstly, that the market is divided between front-loaders and top-loaders and, secondly, that top-loaders are more heterogeneous than the front-loaders, even given product characteristics that are otherwise identical.

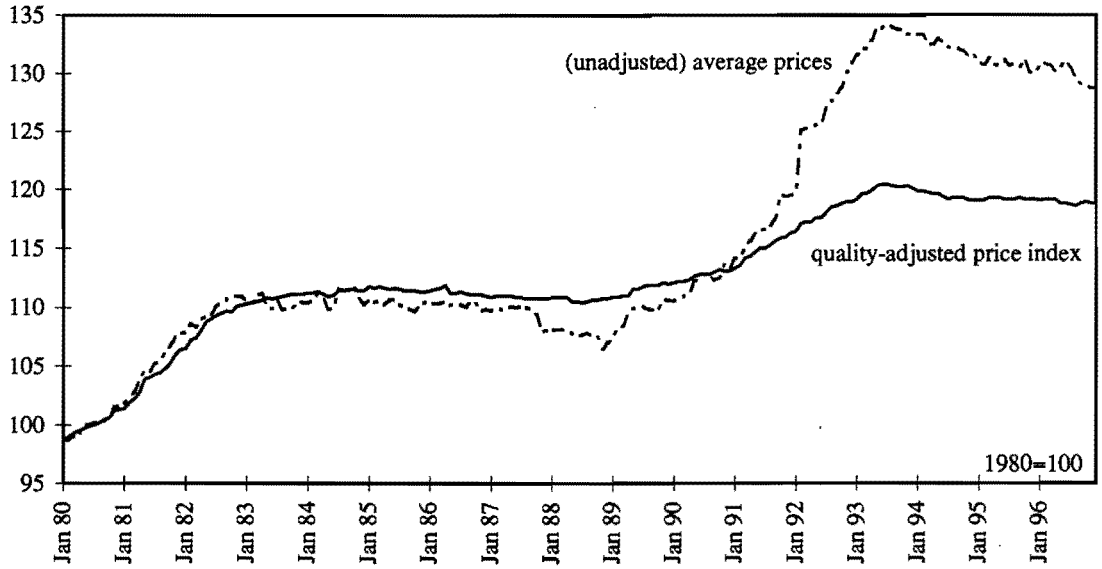
The surveys undertaken by the Federal Statistical Office show that prices of washing machines have risen by a total of just under 30 %, or by an average of 1.7 % p.a., since 1980 (see Chart 5). Adjustments for improvements in quality accounted for less than one-half of these price increases, which means that the index figure included in the calculation of the consumer price index rose by 18.9 %, or 1.1 % p.a. The implicit adjustment for quality of 9.3 % corresponds to a rate of technological progress of 0.6 % p.a. on average.

According to the analysis of the instructions for the quality-adjustment of prices (see p. 45 ff.) it may be expected that fewer adjustments are undertaken on average in times of

Table 11: Washing machines in the Consumer Price Index

Basket of goods	Specification	Relative importance	Average price at the beginning	Average price at the end
1980	Fully automatic washing machine, programmable, cylinder system, for 4-5 kg dry laundry	0.245 %	901.77 DM (01/1980)	1002.44 DM (09/1989)
1985	Fully automatic washing machine, programmable, cylinder system, for 4-5 kg dry laundry (until 12/1992)	0.167 %	1010.73 DM (01/1985)	1079.91 DM (12/1991)
	Fully automatic washing machine for 4-5 kg dry laundry (from 01/1992)		1120.10 DM (02/1992)	1166.44 DM (12/1992)
1991	Fully automatic washing machine for 4-5 kg dry laundry	0.216 %	1043.72 DM (01/1991)	1173.50 DM (05/1997)

Chart 5: Price trends of washing machines



more or less stable price than in times of moderate price increases. Accordingly, the entire period was split into four periods with varying changes in prices (Table 12). The gap between the change in the unadjusted average prices (from the price statistics) and the quality-adjusted price index is used as a measure of the adjustment for changes in quality made by the price statisticians.

In detail, the following picture was obtained:

- Up to autumn 1982 prices for washing machines rose sharply. The quality-adjusted change in the index figure hardly differs from the change in the average prices. An adjustment of the price increases for changes in quality did not take place on average. According to the analysis of the instructions on the quality adjustment of price changes, larger adjustments would really have been to be expected during that period; it was not possible, however, to find out why no adjustments were made.
- Up to end of 1988, a period of broadly stable prices ensued. Average prices even declined slightly from the mid-eighties onwards; the quality-adjusted index-figure remained unaltered, however, so that the quality adjustment was, in fact, negative!
- The period from November 1988 up to and into 1993 shows sharp increases in prices. However, the picture is distorted insofar as at least some price statisticians used the modification of the specification at the beginning of 1992 as an occasion to switch to

Table 12: Changes of prices and quality in the price index for washing machines (in % per annum)

Period	Unadjusted average prices	Quality adjusted price index	Implied change in quality
01/1980-10/1982	+ 4.3	+ 3.9	+ 0.4
10/1982-11/1988	- 0.7	+ 0.2	- 0.8
11/1988-07/1993,			
of which			
11/1988-01/1992	+ 3.8	+ 1.6	+ 2.1
02/1992-07/1993	+ 5.1	+ 2.0	+ 3.0
07/1993-12/1996	- 1.2	- 0.4	- 0.8

models of a higher price segment. These changes took place during 1992, principally in February. Between January and February 1992 the average price rose by 4.5 %, and the index figure rising by as much as 0.6 %. This means that a considerable part of the total quality adjustment is attributable to this change of market segment! In the period between February 1992 and July 1993, the change in average prices amounted to + 5.1 % p.a., the change in the index figure being only 2.0 % p.a. Hence, during this period of sharp price increases, more than one-half of the rise in prices was eliminated as being an advance in quality. If this result is annualised, this implies an increase in quality of 3.0 % per annum.

- From mid-1993 onwards, the prices of washing machines fell. The price index also showed a decline in line with this. The decline in the average prices, totalling - 4.1 % up to the end of 1996, was more marked than the decline in the index figure. During that period, the implicit quality index figure showed a decline of - 2.7 %, or 0.8 % per annum.

On the assumption that the advance in quality of washing machines is not correlated with the true rate of price increase, many factors seem to support the thesis that changes in quality may be adequately taken into consideration in the case of moderately rising prices, but that the generalising procedure of the Federal Statistical Office results in the true rate of price increase being dramatically overstated at times of stagnating or even declining prices.

If a constant advance in quality of 2 % p.a. is assumed, there would have had to have been sharp falls in the quality-adjusted prices of washing-machines in the mid-eighties and mid-nineties. However, it cannot generally be ruled out that enterprises forgo improvements in

quality during periods of price stability, since price adjustments could be particularly expensive during such periods. On the other hand, improvements in the quality of products can be particularly effective in terms of sales if prices are stable. At all events, the data from the product tests do not give any indications of standstills in the advance in quality during the mid-eighties (see Table 13).

However, it might also be conceivable that stagnating, on even declining prices, during the second and the fourth periods were caused by some reporting units switching to less expensive market segments; after all, price statisticians are required to monitor the model that has the highest turnover (see p. 41). A replacement of price representatives would be called for if, for example, stagnating incomes and increased employment risks cause households to switch over to models which are not so sophisticated in terms of quality but less expensive. In that case, average prices would fall, but the accompanying decline in quality should be extracted from the price index. Accordingly, an implicit decline in quality would be obtained, even if prices were adequately adjusted for the ongoing improvement in quality. This would be a further explanation for the negative quality adjustment when average prices are stagnating.

Therefore, hedonic price estimates are to be used below to examine the question of the true quality-adjusted price change in detail. Since 1980, Stiftung Warentest has presented 24 tests (including 4 updates) for washing machines, comprising between 7 and 30 models (Table 13). In total, the prices and product qualities of 390 models were collected. Some of these models underwent multiple tests, and some of the models within individual tests were identical in construction. The tests refer to front-loaders and top-loaders and cover various market segments ("luxury models", "upper price bracket", etc.). Accordingly, the price range extends from under DM 500 to DM 2,500 (Chart 6).

The prices in the product tests are significantly higher than the average prices in the consumer price statistic. This seems to suggest that mainly less sophisticated models are included in the price statistics. Nevertheless, the prices of the product tests also exhibit a rising trend overall, as can be seen by the regression line. This applies particularly to models of the middle and upper price brackets. By contrast, luxury models (tests 5, 7 and 19) have become only marginally more expensive.

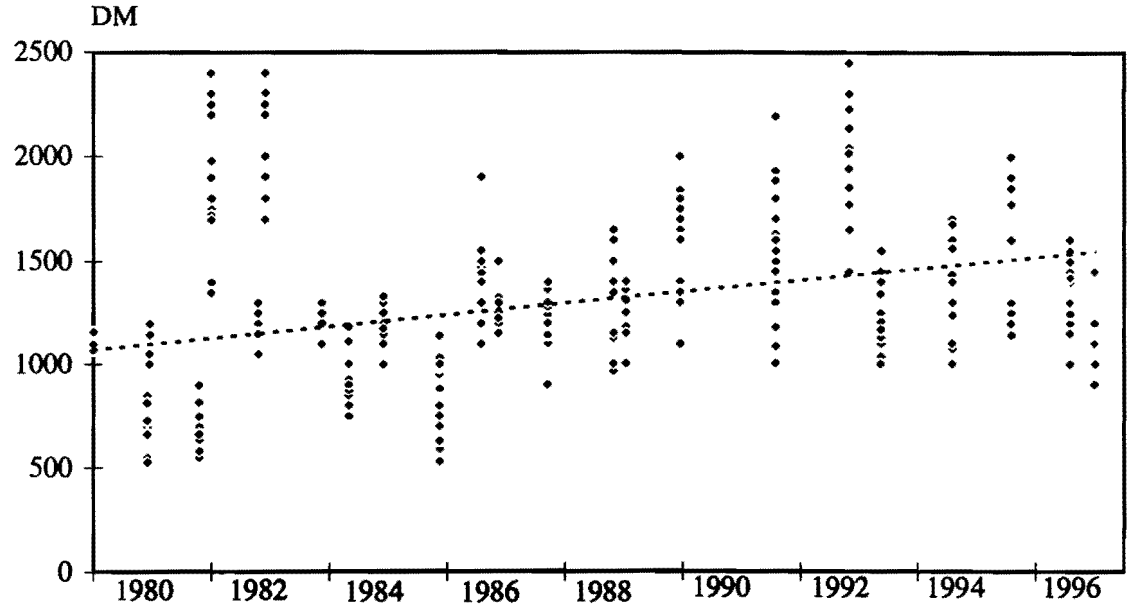
Table 13: Tests of washing machines carried out by Stiftung Warentest

Test no.	Publication	Prices	Market segment	Number of models	Average price (DM)	Average load (kg)	Average maximum spinning speed (rpm)	Average consumption of water (litres per kg laundry)	Average consumption of electricity (kwh per kg laundry)
1	Vol. 4/80	11/79	middle price range	13	1102	4,5	791	33	0,77
2	Vol. 2/81	(10/80)	lower price range	24	689	4,6	492	27	0,59
3	Update of 4/80	10-11/80	middle price range	9	1146	4,6	819	33	0,75
4	Update of 2/81	8-9/81	lower price range	13	911	4,6	621	31	0,59
5	Vol. 3/82, 1/83	11/81	luxury class	15	1935	4,7	1028	27	0,36
6	Vol. 1/83	8-9/82	upper price range	14	1215	4,6	813	28	0,36
7	Vol. 1/83	(10/82)	luxury class	12	2028	4,7	1025	28	0,37
8	Update of 1/83	9-10/83	upper price range	10	1234	4,7	816	28	0,36
9	Vol. 8/84	2-4/84	space-saving models	15	950	4,4	471	27	0,39
10	Vol. 5/85	9-11/84	upper price range	18	1190	4,6	836	25	0,36
11	Vol. 5/86	9-10/85	lower price range	30	784	4,5	461	26	0,37
12	Vol. 11/86	6/86	upper price range	16	1380	4,7	1004	22	0,31
13	Vol. 4/87	9-10/86	space-saving models	16	1264	4,5	834	25	0,37

Table 13 contd.: Tests of washing machines carried out by Stiftung Warentest

Test no.	Publication	Prices	Market segment	Number of models	Average price (DM)	Average load (kg)	Average maximum spinning speed (rpm)	Average consumption of water (litres per kg laundry)	Average consumption of electricity (kwh per kg laundry)
14	Vol. 5/88	6-9/87	middle price range	22	1219	4,7	848	23	0,28
15	Vol. 4/89	9/88	middle price range	15	1378	4,8	975	19	0,27
16	Update of 5/88	11-12/88	middle price range	20	1360	4,7	855	23	0,28
17	Vol. 4/90	9-12/89	upper price range	14	1591	4,9	1127	17	0,25
18	Vol. 10/91	6/91	space-saving models	26	1544	4,5	998	21	0,31
19	Vol. 1/93	9/92	luxury class	15	2002	4,9	1341	15	0,23
20	Vol. 10/93	2-5/93	middle price range	12	1232	4,6	862	19	0,25
20	Vol. 10/93	2-5/93	space-saving models	8	1427	4,5	860	18	0,24
21	Vol. 10/94	6/94	middle price range	16	1409	4,8	1000	14	0,21
22	Vol. 10/95	6/95	upper price range	14	1589	4,9	1200	12	0,21
23	Vol. 10/96	6/96	space-saving models	16	1371	4,3	984	15	0,22

Chart 6: Prices of washing machines in product tests



Even at first glance, what is striking in the quality data that modern washing machines consume much less ELECTRICITY AND WATER per washing cycle than their predecessor models of the early eighties (see Table 13). Since then, water consumption has halved, and the consumption of electricity has declined to one-third. The consumption of washing powder is likely to have declined in the same way.[1] In all market segments, the maximum spinning speed was raised significantly. In the first half of the eighties, a maximum spinning speed of 800 rpm was typical of models belonging to the middle range; in the mid-nineties, it was 1,000 rpm. Thus, in that respect models of the central market segment achieved a level of performance that was typical of luxury models in the early eighties. At the same time, the middle range models also consumed far fewer resources in the mid-nineties than the older models of the upper range. Such luxury models achieved a price of about DM 2,000 in the early eighties (test no. 5), and corresponding middle range models (tests nos. 21 and 22) fetched about DM 1,500 in the mid-nineties. This price reduction by

[1] However, in interpreting the consumption data, it must be borne in mind that these data refer to different washing programmes. Up to and including test no. 4, the data referred to the 90°C programme, from test no. 5 to test no. 18 to the 60°C energy-saving programme, and from test no. 19 to the 60°C coloureds programme. This change of programmes might present the trends in consumption too favourable. On the other hand, the above-mentioned washing programmes had previously not been available, or their performance had not been satisfactory. Since the early eighties, however, the 60°C washing programmes have become so efficient - not least due to progress in washing agent technology - that the 90°C programme, which is wasteful in terms of consumption of resources, can be dispensed with in almost all cases.

Table 14: Price trends of washing machines

	(11/1979-11/1996)		(08/1982-10/1995)	
	Price index	Product tests (n=390)	Price index	Product tests middle range (n=141)
C(1)	4.51	6.91	4.5	7.10
t-statistic	1596.5	207.2	1863.7	385.0
TIME	0.000751	0.002173	0.000604	0.001231
t-statistic	31.1	8.2	22.1	4.5
R^2	0.83	0.16	0.76	0.12
Change in prices (in % p.a.)	+ 0.9	+ 2.6	+ 0.7	+ 1.5

one-fourth within 12 years, or by approximately 2 ¼ % p.a., can therefore be considered to constitute an initial approximation to the true quality-adjusted price change.

The following hedonic price estimates therefore refer, firstly, to the sample as a whole, and, secondly, solely to the middle range (excluding space-saving models or test updates). The first test, too, was disregarded in the smaller sample (due to the consumption data for the 90°C programme). This second sample thus comprises tests nos. 6, 10, 12, 14, 15, 17, 20, 21, and 22, involving a total of 141 models.

For a comparison of the price trends in the price statistics with those of the product tests, the index figures and the prices of the dated models have been regressed to a simple time trend (see Table 14). This will be useful later on as a reference to the quality-adjusted price trends. Accordingly, the average rate of price increases during the period observed was just under 1 % in the case of the index figures[1], 2 ½ % in the sample as a whole, and 1 ½ % for the middle range.

The following tables show the hedonic price estimates for washing machines. The last two lines of each table contain the quality-adjusted price change, which was calculated according to equation 11 (see p. 62) from the coefficient of the time variable (TIME), and the

[1] The average growth rate of the index figures, obtained by simple regression to a time trend, deviates from the results above (p. 70 ff.), since - in contrast to the regression - it was measured from the starting point to the end point. The results would only tally if the regression line were coincidentally to pass precisely through the starting and end values.

Table 15: Price-determining characteristics of washing machines

Variable	
TOP	Dummy=1 for top-loaders.
LOAD	Maximum load in kg dry laundry.
RPM	Maximum spinning speed in revolutions per minute. The measured spinning speed was used, insofar as this was ascertained.
ELEC	Consumption of electricity in kwh per machine load (up to and including test no. 4 for the 90°C programme, then up to test no. 18 for the energy-saving programme at 60°C; finally, from 1993, for the coloureds programme at 60°C).
WATER	Consumption of water for one machine load (up to and including test no. 4 for the 90°C programme, then up to test no. 18 for the 60°C energy-saving programme; finally, from 1993, for the 60°C coloureds programme).

average bias; this resulted from the gap between the rate of change in the (quality-adjusted) price index (Table 14) and the quality-adjusted price change according to the hedonic estimate.

In interpreting the results, and especially when comparing these results with the index figure of the Consumer Price Index, it must be borne in mind that the various sub-samples alternately cover different market segments and that their composition does not necessarily correspond to the appliances for which prices are surveyed as part of the official statistics. Differences between the price trends at the price statistics reporting units and those at the outlets at which Stiftung Warentest surveys prices may affect the result, too. Thus, a possible outlet substitution bias would be included here, too.[1] The most important results of the hedonic estimates may be summarised as follows:

- In general, the explanatory variables (Table 15) have the expected signs and are by and large plausible in terms of their order of magnitude. Top-loaders fetch a high premium; higher prices are likewise asked for a larger capacity and a higher spinning speed. Of the two variables for the consumption of resources, either the coefficient of water consumption or the coefficient of electricity consumption is statistically significant with the anticipated sign. Brand dummies improve the adjustment of the hedonic equations to the data.

[1] See, in particular, Triplett/McDonald (1977) on the problems arising when the results of the price statistics are compared with those of hedonic estimates based on different data records.

Table 16: Quality-adjusted price changes of washing machines

(11/1979-11/1996)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	11	11	11
C	42.18	6.03	1.14	131.55	6.12	2.08
t-statistic	0.3	43.5	3.5	0.9	44.8	6.3
TOP	143.16	0.13	0.12	127.96	0.11	0.10
t-statistic	6.6	7.0	5.9	6.7	7.1	6.3
LOAD	65.55	0.052	0.32	53.13	0.04	0.26
t-statistic	2.2	1.8	2.8	1.7	1.3	2.3
RPM	1.41	0.001	0.85	1.18	0.001	0.74
t-statistic	20.5	26.6	26.7	17.0	22.2	22.5
ELEC	-86.2	-0.11	-0.17	-63.33	-0.09	-0.11
t-statistic	-4.9	-5.6	-3.9	-3.8	-4.7	-2.8
WATER	-0.19	0.001	-0.009	-0.26	0.001	-0.05
t-statistic	-0.3	1.7	-0.2	-0.5	1.1	-1.0
TIME	-0.001166	-0.001432	-0.001471	-0.000863	-0.001137	-0.001166
t-statistic	-4.5	-4.3	-4.0	-3.4	-3.7	-3.5
n	390	390	390	390	390	390
adj. R^2	0.78	0.78	0.77	0.81	0.82	0.81
SE	0.15	0.15	0.16	0.14	0.14	0.14
Quality-adjusted price change (in % p.a.)	- 1.4	- 1.7	- 1.7	- 1.0	- 1.4	- 1.4
Bias (in percentage point p.a.)	2.3	2.6	2.6	1.9	2.3	2.3

- On the whole, the statistical fit for the large sample (Table 16) is much better than for medium-range models (Table 17) alone. In addition, there are minor advantages for the semi-logarithmic model. Otherwise, the various specifications scarcely differ in terms of their explanatory value.
- The time variable has a negative sign throughout. For the large sample (Table 17), it is statistically significant at a 95 % level to be below zero for all variants; in the small sample (Table 18), however, this is not achieved in any of the cases. Brand dummies increase the quality-adjusted price rise. The quality-adjusted price change is smaller in the non-linear approaches than in the linear models.

Table 17: Quality adjusted price changes of washing machines
(middle and upper price range)

(8/1982-10/1995)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	4	4	4
C	295.13	6.18	3.93	384.37	6.29	3.87
t-statistic	0.6	16.7	3.1	0.8	17.4	3.3
LOAD	142.43	0.16	0.60	78.69	0.11	0.34
t-statistic	1.6	2.5	1.7	0.9	1.6	1.0
RPM	0.74	0.001	0.51	0.82	0.001	0.56
t-statistic	4.2	4.8	4.3	5.0	5.6	5.3
ELEC	19.35	0.019	0.06	53.49	0.033	0.088
t-statistic	0.2	0.3	0.9	0.7	0.6	1.2
WATER	-3.15	-0.003	0.24	-2.72	-0.002	-0.24
t-statistic	-2.7	-3.1	-2.9	-2.4	-2.9	-2.9
TIME	-0.000631	-0.000920	0.000689	-0.000452	-0.000802	-0.000605
t-statistic	-1.4	-1.8	-1.2	-1.0	-1.6	-1.1
n	141	141	141	141	141	141
adj. R^2	0.45	0.49	0.46	0.48	0.52	0.50
SE	0.13	0.12	0.12	0.12	0.12	0.12
Quality-adjusted price change (in % p.a.)	- 0.8	- 1.1	- 0.8	- 0.5	- 1.0	- 0.7
Bias (in percentage point p.a.)	1.5	1.8	1.5	1.2	1.7	1.4

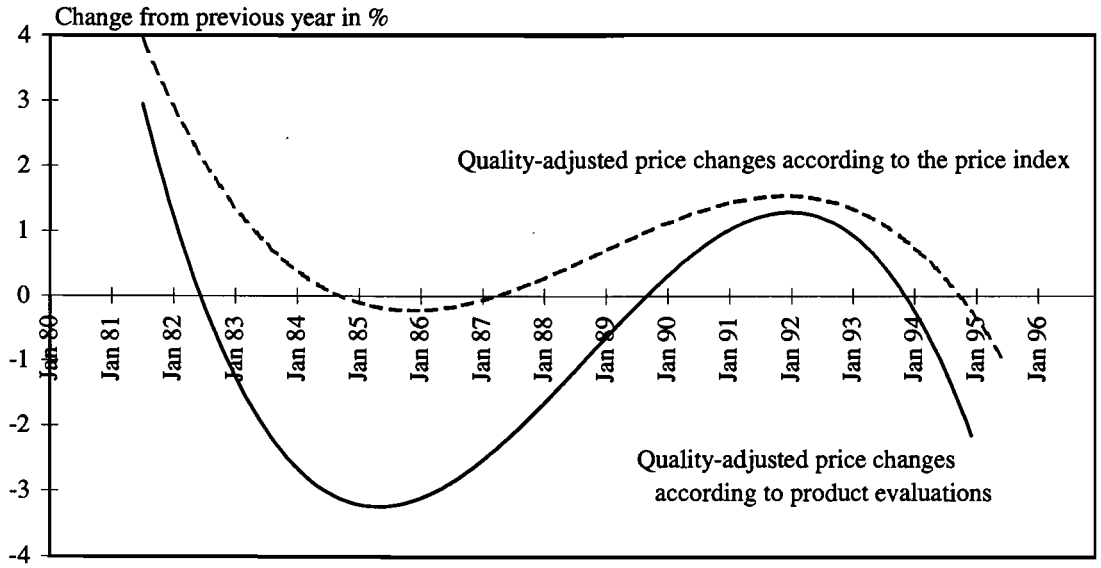
- According to these estimates, the QUALITY-ADJUSTED PRICE CHANGE would have been between -0.5 and -1.7 % p.a. on average during the period observed, rather than just under +1 % p.a., as recorded in the price statistics. The average BIAS would be in an interval between 1 and 2 ½ percentage points p.a..
- The substitution of the time trend by a polynomial further improves the adjustment (Table 18). To facilitate comparison, the corresponding price index has likewise been regressed on a polynomial. The vertical gap between the two curves calculated according to equation 13 (p. 62) for the time-dependent rates of price increases will then indicate the bias (Chart 7). This gap suggests that the bias reached a peak of around 3 % in 1985, a period of stable prices, and that, by contrast, it was negligibly small in 1991 and 1992, when prices were increasing moderately.

Table 18: Flexible price changes of washing machines

(11/79-11/96)	Price index	Product evaluations (semi-log; 4 characteristics 11 brand dummies)
C	4.43	6.03
t-statistic	1823.6	36.5
TIME^1	0.007004	0.009006
t-statistic	41.8	3.2
TIME^2	-0.000120	-0.000212
t-statistic	-35.4	-4.2
TIME^3	$8.34\ 10^{-07}$	$1.57*10^{-06}$
t-statistic	33.1	4.4
TIME^4	$-1.93*10^{-09}$	$-3.73*10^{-09}$
t-statistic	-31.1	-4.4
adj. R^2	0.98	0.83
SE	0.007	0.133

Even though the results of the hedonic price studies for washing machines can be interpreted only with some caution, they nevertheless imply that the advance in quality is not always adequately taken into account in the official price statistics. The approximation of the price trends with the time polynomial suggests that a perceptible bias occurs especially in times of stable or even declining prices. Following the analysis of the rules for quality adjustment, this exactly what was to be expected.

Chart 7: Time-dependent prices changes of washing machines



e) Case Study No. 3: Quality-adjusted Price Changes of Refrigerators

In the German Consumer Price Index the specification for refrigerators - which remained unchanged during the period under observation - is more narrowly defined than is the usual practise (Table 19). Only STAND ALONE-TYPE REFRIGERATORS with a 3-star freezer compartment and an interior volume of approximately 160 litres are considered. BUILT-IN REFRIGERATORS, which have increasingly become popular following the advance of kitchen units, and refrigerators without a freezer compartment have not been included. The latter are particularly popular with larger households which are also equipped with a freezer.

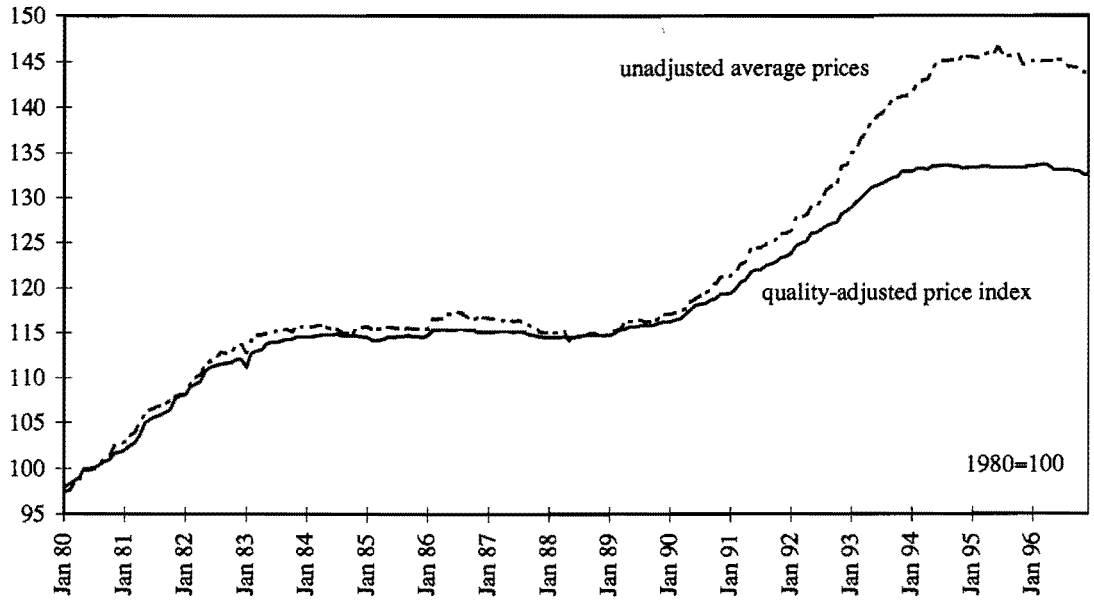
Since 1980, prices for refrigerators have been increased by an average of 44 %, or 2.3 % p.a. (Chart 8). One-quarter of this rise was extracted by the price statisticians as being a remuneration for improvements in quality. This corresponds to an advance in quality of 0.5 % per annum. The index figure has thus gone up by a total of 33 %, or 1.8 % p.a. Similarly to washing machines, dividing the total period into four sub-periods proves to be useful in the case of refrigerators, too (Table 20):

- Up to spring 1984, refrigerators displayed sharp price increases, a small part of which was extracted as being for changes in quality.

Table 19: Refrigerators in the Consumer Price Index

Basket of goods	Specification	Relative importance	Average price at the beginning	Average price at the end
1980	Refrigerator, stand alone model, compression system, 3-star freezer compartment with automatic defrost, interior volume 160 l	0.099%	473.97 DM (01/1980)	566.35 DM (09/1989)
1985	Refrigerator, stand alone model, compression system, 3-star freezer compartment with automatic defrost, interior volume. 160 l	0.048%	563.45 DM (01/1985)	652.29 DM (12/1992)
1991	Refrigerator, stand alone model, compression system, 3-star freezer compartment with automatic defrost, Interior volume approx. 160 l	0.105%	590.30 DM (01/1991)	686.59 DM (05/1997)

Chart 8: Price trends of refrigerators since 1980



- A period of price stability ensued up to the end of 1988. On average, during that period practically no adjustments were made for changes in quality. Rather, the price index for refrigerators grew marginally faster than the corresponding average prices.
- Up to mid-1994, prices then rose sharply; slightly more than one-third of this increase was qualified as being an untrue price change and was extracted. The implicit improvement in quality amounted to around 1.5 % per annum.
- Again, a period of stable prices ensued, during which average prices and the price index displayed largely similar percentage changes.

Here, too, there is confirmation of the impression that price statisticians take into account quality changes quite frequently during periods of moderate to sharp price increases but that this is not the case during periods of price stability.

Table 20: Changes of prices and quality in the price index for refrigerators
(change in % p.a.)

Period	Unadjusted average prices	Quality adjusted price index	Implied change in quality
01/1980-04/1984	+ 4.2	+ 3.8	+ 0.4
04/1980-12/1988	- 0.2	- 0.0	- 0.2
12/1988-06/1994	+ 4.3	+ 2.8	+ 1.5
06/1994-12/1996	- 0.3	- 0.3	- 0.0

Table 21: Tests of refrigerators carried out by Stiftung Warentest since 1980

Test no.	Publication	Prices	Type	Number of models	Average price (DM)	Average interior volume (Litre)	Average consumption of electricity in 24 hours (kWh/100 litres interior volume)
1	Vol. 10/82	5-6/82	***-stand alone model	36	595	141	1,01
2	Vol. 10/86	5/86	***-stand alone model	23	585	143	0,77
3	Vol. 1/87	9/86	***-built-in model	25	887	143	0,65
4	Vol. 1/88	6-7/87	Built-in model	16	765	162	0,46
5	Update of 1/87	7-8/87	***-built-in model	22	936	143	0,65
6	Update of 1/88	5/88	Built-in model	9	725	163	0,44
7	Vol. 6/89	3/89	***-stand alone model	25	591	147	0,66
8	Vol. 1/91	9/90	***-built-in model	17	901	148	0,62
9	Vol. 1/92	8-9/91	Built-in model	18	832	162	0,48
10	Vol. 1/93	8-9/92	***-stand alone model	19	714	141	0,55
11	Vol. 2/93	8-9/92	***-stand alone model	9	753	141	0,59
12	Vol. 3/94	11/93	Stand alone model	10	806	149	0,36
13	Vol. 5/95	1/95	***-stand alone model	18	773	132	0,53
14	Vol. 2/96	10/95	Built-in model	18	1116	156	0,33
15	Vol. 7/97	3/97	***/****-stand alone model	9	788	137	0,41

Table 22: Price trends of refrigerators

	(05/1982-03/1997)		(05/1982-03/1997)	
	Price index	Product evaluations overall (n=266)	Price index	Product evaluations ***-stand alone models (n=130)
C(1)	4.5	6.4	4.5	6.3
t-statistic	1228.5	265.8	1228.5	290.1
TIME	0.001178	0.002105	0.001178	0.001810
t-statistic	33.1	9.0	33.1	9.3
R^2	0.86	0.20	0.86	0.36
Change in prices (in % p.a.)	+ 1.4	+ 2.6	+ 1.4	+ 2.2

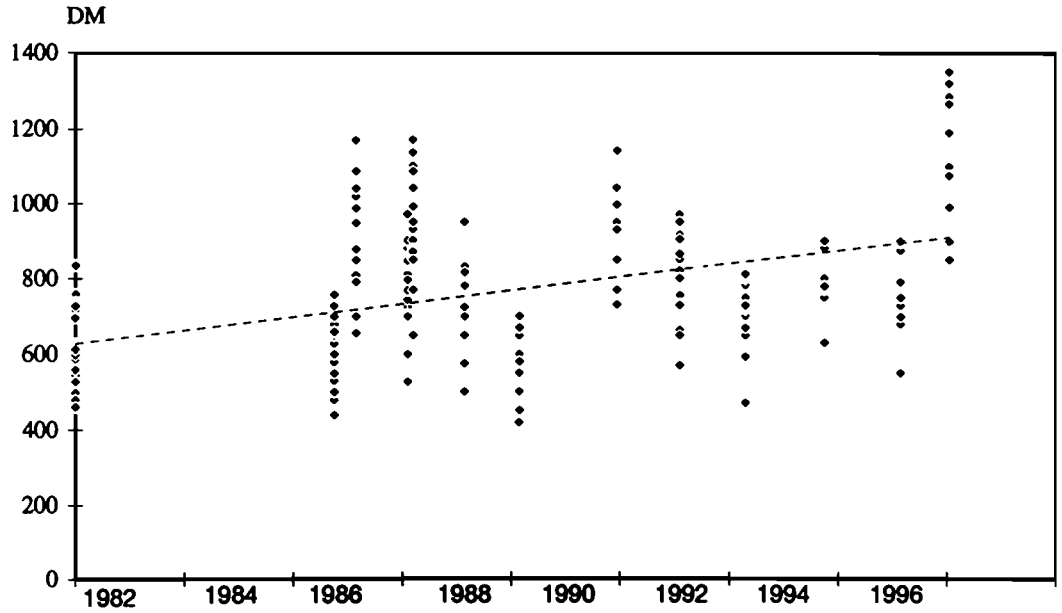
Since 1980, 15 tests of refrigerators involving a total of 266 models have been published in the periodical Warentest (Table 21).[1] Two of these tests were updates of older tests; furthermore, some tests contained identical models that were being sold under different brand names. Up to 1986, only one test was conducted (10/1982), which means that the first period of sharply rising prices is not captured. In addition to stand alone models, built-in models (refrigerators both with and without a freezer compartment) were regularly tested as well. Six tests refer exclusively to ***- stand alone-type freezers and thus come close to the specification of the Federal Statistical Office. Again, two samples were formed, the first of which comprised all the tests, the second one the tests with the numbers 1, 2, 7, 10, 11, 13, and 15. This second sample contains a total of 130 models.

As was the case with washing machines, the index figures from the price statistics and the prices from the product tests were regressed on a time trend (Table 22). According to that regression, the average price rise of the ***-table type appliances was slightly less than 1 percentage point above the rate of price increase recorded in the official price statistics. In absolute terms, however, the average prices for refrigerators in the product tests are somewhat higher (Table 21, Chart 9) than those in the price statistics (Table 19) owing to the fact that built-in appliances are more expensive.

In the hedonic price estimates, the product characteristics shown in table 23 help to explain price differences. The CFC dummy proves to be particularly problematic here. From the

[1] In addition, there were 7 tests of refrigerator freezer combinations, which were, however, not included in the estimates.

Chart 9: Prices of refrigerators in product tests



technological point of view, CHLOROFLUOROCARBONS (CFCs) were considered for a long time to be an almost ideal and, moreover, inexpensive coolant for refrigerators and freezers. Furthermore, the insulating material in the exterior panels contained significant quantities of CFCs. After it became known in the late eighties that CFCs damage the ozone layer, the changeover to CFC-free refrigerators was effected, owing to technical problems, only in a large number of small steps. First, the CFCs content in the insulating foam contained in the exterior panels was gradually reduced, which in some cases entailed a higher

Table 23: Price-determining characteristics of refrigerators

Variable	
UP TO DATE	Dummy=1 for model continuing to be sold with an unaltered specification.
SUB	Dummy=1 for appliances that can be fitted under a working surface.
BUILT-IN	Dummy=1 for appliances that can be fitted.
GP	Dummy=1 for shelves of glass and plastic (instead of gratings).
VOLC	Volume of the cooler compartment (in l).
VOLF	Volume of the ***-freezer compartment (in l).
VOLT	Total interior volume (in l).
FC3	Dummy=1 for ***-freezer compartment.
FC4	Dummy=1 for ****-freezer compartment.
ENERGY	Electricity consumption in Kwh in 24 hours.
CFCs	Dummy=1 for refrigerators without CFCs.

consumption of electricity. Since the consumption of electricity was to be reduced, too, however, because of rising energy costs, the insulating layers were reinforced. With predefined exterior dimensions, this, in turn, resulted in the usable interior volume becoming smaller. At the same time, efforts were being made to save coolants by means of a more efficient design of the refrigeration cycle. Eventually, in 1993 the first refrigerators came on to the market that were able to work entirely without CFCs. Since 1996, the production of household cooling appliances using CFCs as a coolant has been banned in the EC.

For these product improvements to be accurately captured in the estimates, the quantity of CFCs contained in the insulation material and in the refrigeration cycle would have to used as an explanatory quality variable. This is not possible, however, because relevant data are either not available at all for older models (because the harmfulness of CFCs had not yet been recognised), and only incompletely for models manufactured in the first half of the nineties. Since 1994, only CFC-free models have been tested, which can be considered in the estimates by employing dummies. This, however, fails to take into account the sharp decline in the use of CFCs in the first half of the nineties.

As was the case with washing machines, the engineers succeeded in sharply reducing the CONSUMPTION OF ELECTRICITY of refrigerators. Up to the end of the eighties, it had declined by around one-third. Subsequently, it increased again temporarily in the wake of efforts to cut down on the use of CFCs. Since the mid-nineties onwards, it has nevertheless been half of the 1982 level. Other improvements in the quality of refrigerators primarily concern the INTERIOR DESIGN. The gratings were gradually replaced by plastic or glass shelves that are easier to clean and also offer greater stability. In many models the back panel has also been made flatter; it was not possible to take this into account in the estimates, however, owing to lack of adequate information.

In Tables 24 to 27 the results of the hedonic price estimates are shown in almost the same sequence as in the case of washing machines, the only difference being that part of the estimates is represented in two variants: firstly, without a CFC dummy, and secondly, with a CFC dummy. Overall, the estimates produce the following results:[1]

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[1] As in the case of the washing machines, too, when interpreting the results it has to be borne in mind that prices and products in the hedonic price estimates do not tally with those in the price statistics, so that any deviations cannot be explained solely by the differing method of quality adjustment.

Table 24: Quality adjusted price changes of refrigerators (without CFCs-dummy)

(05/1982-03/1997)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	4	4	4
C	211.28	5.85	3.26	233.45	5.90	3.66
t-statistic	2.4	37.7	4.9	2.7	40.4	5.84
UP TO DATE	-44.79	-0.07	-0.07	-45.16	-0.07	-0.07
t-statistic	-2.7	-2.6	-2.7	-2.6	-2.7	-3.0
SUB	36.33	0.07	0.06	52.88	0.09	0.09
t-statistic	2.7	2.7	2.4	4.3	4.4	4.4
BUILT-IN	229.32	0.35	0.33	249.92	0.38	0.37
t-statistic	13.0	12.8	11.6	14.8	15.6	15.3
GP	94.64	0.13	0.12	104.98	0.15	0.14
t-statistic	5.2	5.7	5.1	6.0	6.9	6.1
VOLCT	-	-	0.60	-	-	0.51
t-statistic	-	-	4.6	-	-	4.1
VOLC	2.48	0.004	-	2.11	0.003	-
t-statistic	5.1	4.6	-	4.4	4.2	-
VOLF	8.53	0.014	-	7.28	0.012	-
t-statistic	6.7	6.8	-	5.8	6.3	-
FC3	-	-	0.18	-	-	0.16
t-statistic	-	-	5.3	-	-	4.9
FC4	-54.62	-0.08	-0.09	-51.88	-0.07	-0.09
t-statistic	-2.1	-2.1	-2.9	-2.7	-2.4	-3.3
ENERGY	-86.18	-0.19	-0.23	-65.62	-0.17	-0.22
t-statistic	-2.4	-3.2	-4.5	-1.8	-3.0	-4.5
TIME	0.000996	0.000850	0.000546	0.000914	0.000713	0.000390
t-statistic	3.1	2.7	1.9	3.0	2.4	1.5
n	275	275	275	275	275	275
adj. R^2	0.67	0.68	0.68	0.70	0.71	0.71
SE	0.137	0.136	0.134	0.132	0.129	0.128
Quality-adjusted price change (in % p.a.)	+ 1.2	+ 1.0	+ 0.7	+ 1.1	+ 0.9	+ 1.1
Bias (in percentage point p.a.)	0.2	0.4	0.7	0.3	0.5	0.3

Table 25: Quality adjusted price changes of ***- stand alone refrigerators (without CFCs-dummy)

(05/1982-03/1997)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	3	3	3
C	219.41	5.72	2.75	234.50	5.74	3.40
t-statistic	2.3	31.0	4.2	2.5	32.9	5.6
UP TO DATE	-58.92	-0.01	-0.10	-55.86	-0.09	-0.10
t-statistic	3.4	-3.6	-3.7	-3.3	-3.6	-3.7
SUB	30.88	0.05	0.05	46.48	0.09	0.09
t-statistic	2.1	2.0	2.1	3.8	4.1	4.3
GP	53.88	0.08	0.07	79.42	0.13	0.11
t-statistic	2.9	2.8	2.1	4.3	4.5	3.7
VOLT	2.96	0.005	0.74	2.38	0.004	0.59
t-statistic	5.6	5.4	5.6	4.7	4.8	4.8
ENERGY	-42.79	-0.06	-0.13	-13.16	-0.01	-0.08
t-statistic	-0.9	-0.7	-1.6	-0.3	-0.2	-01.0
TIME	0.001224	0.001325	0.001083	0.001052	0.001107	0.000883
t-statistic	3.0	3.1	2.9	2.8	2.8	2.5
n	139	139	139	139	139	139
adj. R^2	0.56	0.55	0.55	0.62	0.62	0.62
SE	0.12	0.12	0.12	0.11	0.11	0.11
Quality-adjusted price change (in % p.a.)	+ 1.5	+ 1.6	+ 1.3	+ 1.3	+ 1.3	+ 1.1
Bias (in percentage point p.a.)	- 0.1	- 0.2	0.1	0.1	0.1	0.3

- In all the estimates that were pooled over time without a CFCs dummy, the time variable has a positive sign and is statistically significant at a high level to be above zero (Tables 24 and 25). The quality-adjusted increase in prices is smaller in the overall sample than in the sub-sample of the stand alone-type refrigerators. As expected, in some cases supplementing the explanatory variable with the CFC dummy (Tables 26 and 27) reduces the average price rise by more than 1 percentage point. In all specifications, there is no longer a probability of more than 95 % that the time variable differs from zero. This means that it is not possible to rule out a true quality-adjusted rate of price increase of zero.

Table 26: Quality adjusted prices changes of refrigerators
(with CFCs-dummy)

(05/1982-03/1997)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	4	4	4
C	-33.00	5.47	2.01	-4.27	5.53	2.45
t-statistic	-0.3	37.1	3.1	-0.0	39.1	3.9
UP TO DATE	-28.83	-0.03	-0.03	-28.32	-0.04	-0.04
t-statistic	-1.7	-1.4	-1.4	-1.6	-1.5	-1.7
SUB	38.31	0.08	0.07	51.73	0.11	0.10
t-statistic	2.9	3.8	3.4	3.8	5.1	5.2
BUILT-IN	283.22	0.40	0.37	297.71	0.43	0.41
t-statistic	15.0	16.8	14.9	16.0	18.4	18.0
GP	92.15	0.12	0.12	101.73	0.13	0.16
t-statistic	5.1	5.9	5.4	6.0	7.1	6.5
VOLT	-	-	0.84	-	-	0.74
t-statistic	-	-	6.5	-	-	6.1
VOLC	3.77	0.006	-	3.37	0.005	-
t-statistic	7.1	7.5	-	6.5	7.0	-
VOLTF	13.39	0.020	-	12.04	0.018	-
t-statistic	9.4	10.3	-	8.4	9.7	-
FC3	-	-	0.23	-	-	0.21
t-statistic	-	-	6.8	-	-	6.4
FC4	-115.68	-0.14	-0.14	-111.28	-0.13	-0.13
t-statistic	-3.6	-3.5	-4.1	-4.3	-4.2	-4.9
ENERGY	-81.83	-0.17	-0.16	-61.71	-0.16	-0.15
t-statistic	-2.4	-3.3	-3.3	-1.8	-3.1	-3.3
CFCs	194.93	0.26	0.21	186.75	0.25	0.20
t-statistic	6.9	8.4	7.1	6.9	8.6	7.4
TIME	-0.000105	-0.000319	-0.000198	-0.000109	-0.000386	-0.000306
t-statistic	-0.3	-1.0	-0.7	-0.4	-1.3	-1.1
n	275	275	275	275	275	275
adj. R^2	0.74	0.75	0.73	0.76	0.77	0.76
SE	0.123	0.120	0.125	0.118	0.114	0.118
Quality-adjusted price change (in % p.a.)	- 0.1	- 0.4	- 0.2	- 0.1	- 0.5	- 0.4
Bias (in percentage point p.a.)	1.5	1.8	1.6	1.5	1.9	1.8

Table 27: Quality adjusted price changes of ***-stand alone refrigerators (with CFCs dummy)

(05/1982-03/1997)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	3	3	3
C	94.18	5.51	1.83	144.80	5.6	2.6
t-statistic	0.9	30.0	2.8	1.6	33.5	4.4
UP TO DATE	-47.62	-0.07	-0.08	-46.79	-0.07	-0.07
t-statistic	-2.9	-3.0	-3.1	-2.7	-2.9	-2.6
SUB	37.07	0.07	0.06	47.48	0.09	0.09
t-statistic	2.7	2.9	2.9	3.8	4.6	4.8
GP	51.89	0.08	0.06	75.79	0.12	0.10
t-statistic	2.6	2.6	2.0	4.0	4.1	3.5
VOLT	-	-	0.92	3.15	0.005	0.74
t-statistic	-	-	7.0	5.9	6.1	6.0
VOLC	3.56	0.006	-	-	-	-
t-statistic	5.6	5.6	-	-	-	-
VOLF	7.04	0.01	-	-	-	-
t-statistic	1.9	2.2	-	-	-	-
FC4	-56.78	-0.09	-0.11	-59.69	-0.09	-
t-statistic	-2.0	-2.2	-2.8	-3.2	-3.7	-
ENERGY	-61.98	-0.10	-0.14	-26.37	-0.04	-0.08
t-statistic	-1.3	-1.2	-1.9	-0.6	-0.5	-1.1
CFCs	111.53	0.17	0.17	95.52	0.15	0.13
t-statistic	4.1	4.8	4.8	3.9	4.7	4.2
TIME	0.000460	0.000527	0.000420	0.000479	0.000480	0.000319
t-statistic	1.0	1.2	1.1	1.2	1.1	0.9
n	139	139	139	139	139	139
adj. R^2	0.61	0.61	0.62	0.67	0.67	0.66
SE	0.11	0.11	0.11	0.10	0.10	0.10
Quality-adjusted price change (in % p.a.)	+ 0.6	+ 0.6	+ 0.5	+ 0.6	+ 0.6	+ 0.4
Bias (in percentage point p.a.)	0.8	0.8	0.9	0.8	0.8	1.0

- Most of the other explanatory variables have the anticipated signs and, as a rule, are significant to be above zero. Only the dummy for up-to-dateness and the dummy for a four-star freezer compartment consistently display a negative sign. Including brand

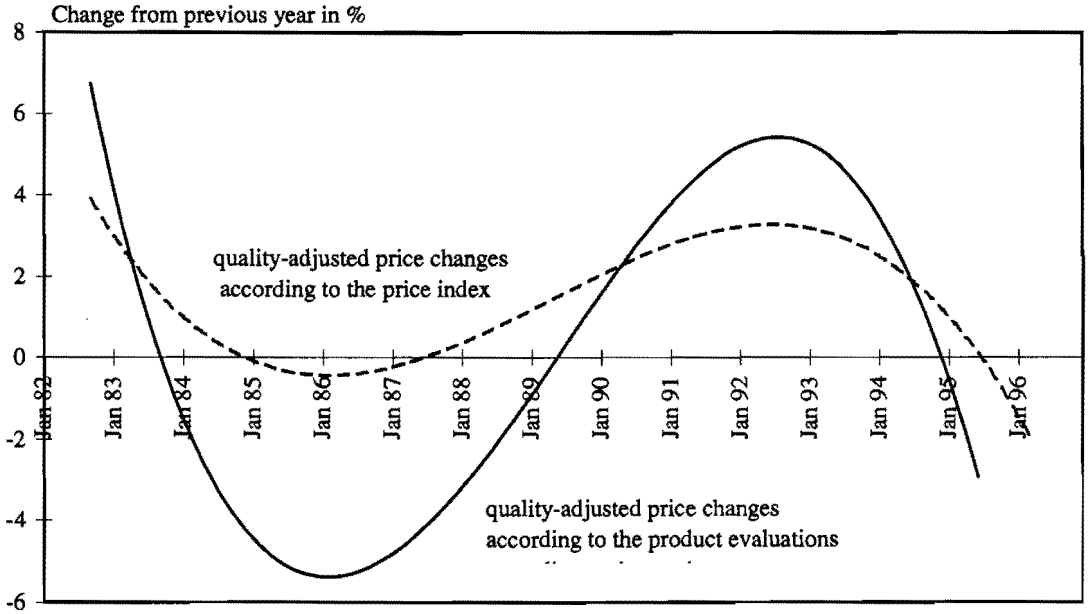
Table 28: Flexible price changes of refrigerators

(11/79-11/96)	Price index	Product evaluations (semi-log; 6 characteristics incl. CFC-dummy)
C	4.50	5.41
t-statistic	2093.7	39.0
TIME^1	0.003902	0.007496
t-statistic	22.8	2.6
TIME^2	-0.000110	-0.000311
t-statistic	-27.5	-3.9
TIME^3	$1.13*10^{-06}$	$3.19*10^{-06}$
t-statistic	32.9	4.5
TIME^4	$-3.42*10^{-09}$	$-9.59*10^{-09}$
t-statistic	-35.1	-4.9
adj. R^2	0.99	0.78
SE	0.006	0.11

dummies, only a few of which are statistically significant, improves the fit as a whole without having any significant impact on the other results.

- As expected, the coefficient of energy consumption is negative and in many cases quite plausible in terms of its size. In most cases, it is statistically significant to be above zero only in the overall sample, but not for stand alone-type refrigerators alone. This applies irrespective of whether a CFC dummy has been included or not.
- As in the case of washing machines, adjusting the estimate model works slightly better in the large sample than in the more homogenous mass of ***-stand alone-type refrigerators. However, in terms of the explanatory value of the three specifications, these differences tend to be slight and also to differ depending on the variant. Here, too, the quality-adjusted price rise is, in most cases, smaller in the non-linear specifications than in the linear variant.
- According to these estimates, the QUALITY-ADJUSTED PRICE RISE OF REFRIGERATORS was between just over ½ % and 1 ½ % per annum, with the quality-adjusted price trends of ***stand alone refrigerators (Table 25) being almost identical to the average change in the corresponding price figure in the Consumer Price Index; if the other refrigerator types are also included, an average bias of less than ½ percentage point would be obtained (Table 24). The picture changes if the CFCs dummy is included. In that case, a bias of at least 1 ½ percentage point would be obtained for the

Chart 10: Time-dependent price changes of refrigerators



entire sample (Table 26), and of 0.8 percentage point for stand alone-type refrigerators (Table 27).

- As in the case of washing machines, the use of a polynomial considerably improves the adjustment of the estimates (Table 28). Owing to the limited space available in this study, only one estimate for the refrigerators is presented here, too, and compared with the corresponding results for the price index. Even though the results must be interpreted with the necessary caution, the impression that the measurement bias varies with the rate of price increases itself is again confirmed (Chart 10). This suggests that the bias was at its greatest during the period of declining rates of inflation in the mid-eighties, whereas it was, in fact, negative from 1991 to 1993 This, however, may also have to do with the fact that it was not possible to take adequate account of the reduction in the use of CFCs.

Accordingly, the calculations for refrigerators also broadly confirm the hypothesis that the official price indices tends to overstate the true rate of price increase in times of stable prices, and especially in times of declining prices. With above-average rates of price increase, a negative bias sets in with refrigerators; the main reason for this, however, is likely to be that the changeover to CFC-free refrigerators took place in a period of sharp price increases and, furthermore, that it was not possible to capture this adequately in the estimates.

f) Case Study No. 4: Quality-adjusted Price Changes of Freezers

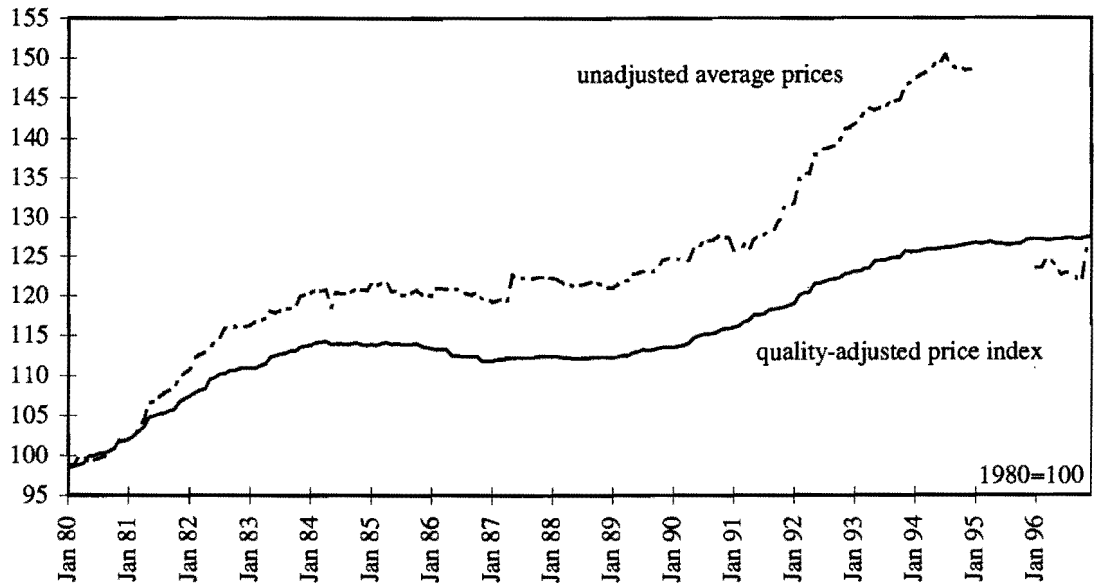
Similarly to refrigerators, the specification of freezers in the German Consumer Price Index is defined in comparatively narrow terms (Table 29). Only upright freezers are expressively named as price representatives, rather than the less sophisticated chest-type freezers. Furthermore, an essential quality feature has been specified quite precisely by including the interior volume. In the period under review, the specification of the freezers was altered no more than once, namely at the beginning of 1996, with the interior volume being reduced by 50 %.

Measured by the index figure for freezers, the price trend (Chart 11) was similar to that of refrigerators: a period of sharp price rises is followed by no more than slight increases in prices, after which there is again a period of accelerated inflation. In contrast to refrigerators and washing machines, net adjustments for changes in quality were undertaken during the period of relative price calm, too. On the whole, the prices of freezers rose by 49 %, or 2.9 % p.a. up to the end of 1994, 27 % (1.7 % p.a.) of which was rated as a true increase in price, and 17 %, or 1.2 % p.a., as being for changes in quality.

Table 29: Freezers in the Consumer Price Index

Basket of goods	Specification	Relative importance	Average price at the beginning	Average price at the end
1980	Upright freezer with a pre-freezing compartment and a quick-freezing facility; approx. 300 l capacity	0.065 %	831.56 DM (01/1980)	1036.95 DM (09/1989)
1985	Upright freezer with a pre-freezing compartment and a quick-freezing facility; approx. 300 l capacity	0.069 %	1021.92 DM (01/1985)	1197.77 DM (12/1992)
1991	Upright freezer with a pre-freezing compartment and a quick-freezing facility; approx. 300 l capacity	0.128 %	1059.05 DM (01/1991)	1250.47 DM (12/1994)
	Upright freezer: approx. 150 l capacity (from 01/1996)		1040.00 DM (01/1996)	1045.97 DM (05/1997)

Chart 11: Price trends of freezers



Three chief periods with differing price trends can be isolated (owing to the change in the specification, it is not possible to analyse the mid-nineties, when the prices of the other goods were stagnating, in greater detail) (Table 30):

- In the early eighties, there were sharp increases in prices; in contrast to washing machines and refrigerators, slightly more than one-quarter of this was eliminated as a change in quality.
- This was followed by a period of stable prices from 1984 onwards. During that time the price index declined, corresponding to an implicit quality adjustment of approximately ½ % per annum.
- From 1989 onwards, freezers, too, again showed sharper price increases. Almost one-half of this price increase was qualified by the statistical offices as being for changes in quality and was extracted.

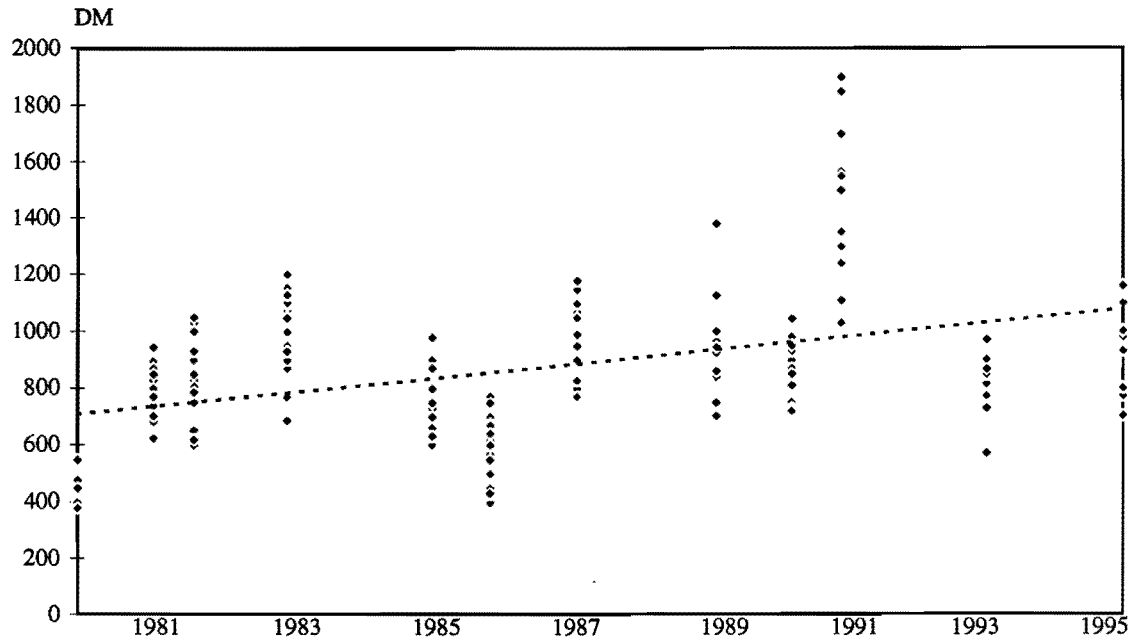
Table 30: Changes of prices and quality in the price index for freezers
(in % per annum)

Period	Unadjusted average prices	Quality adjusted price index	Implied change in quality
01/1980-02/1984	+ 5.0	+ 3.7	+ 1.3
02/1984-01/1989	+ 0.0	- 0.3	+ 0.4
01/1989-07/1994	+ 4.0	+ 2.1	+ 1.8

Table 31: Tests of freezers carried out by Stiftung Warentest

Test no.	Publication	Prices	Type	Number of models	Average price (DM)	Average interior volume (litre)	Average consumption of electricity per day (kWh/100 Litres interior volume)	Average time consumed for a rise in temperature from - 18°C to - 9°C in the event of power failure (hours)
1	6/80	3/80	Upright freezers	15	467	95	1,18	16
2	6/81	2/81	Upright freezers	20	780	184	0,87	16
3	6/82	1/82	Chest-type freezers	21	825	275	0,51	33
4	7/83	3/83	Upright freezers	27	993	206	0,69	22
5	9/85	3-5/85	Chest-type freezers	22	767	253	0,42	41
6	5/86	1/86	Upright freezers	26	574	101	1,12	21
7	9/87	5/87	Upright freezers	19	960	199	0,59	33
8	9/89	5/89	Built-in upright freezers	21	949	105	0,99	18
9	10/90	6/90	Chest-type freezers	20	876	259	0,32	47
10	7/91	2-3/91	Upright freezers	17	1443	244	0,45	31
11	8/93	3-4/93	Upright freezers	12	832	102	0,76	37
12	9/95	3/95	Chest-type freezers	12	963	231	0,35	48

Chart 12: Prices of freezers in product tests



Thus, the implicit quality changes of freezers are distributed more evenly than those of the other goods considered above. One of the reasons for this could be the overall rate of price increases being somewhat higher in the case of freezers. As a consequence, price reductions occurred more rarely even in periods of overall price stability, which means that the combination of an improvement in quality and a lowering of price - which is especially problematical from the point of view of price measurement - manifests itself less frequently. Another reason might be the very narrow product specification, which covers only a small segment of the market. A substitution of the price representatives combined with a change to a different segment of the market - due to a change in importance in terms of turnover - is thus virtually ruled out.

Between 1980 and 1995 the Stiftung Warentest published 12 tests of freezers (Table 31). one-third of which referred to chest-type freezers (75 models), and two-thirds to upright freezers (157 models). A total of three samples was formed, the first sample comprising all the tests, the second sample the tests of upright freezers (with the exception of one test involving built-in upright freezers), and the third sample the tests of chest-type freezers.

The prices of the freezers in the product tests ranged from DM 400 to almost DM 2.000. the majority of models costing slightly less than DM 1.000 (Chart 12). Thus, they were

Table 32: Price trends of freezers

	(06/1980-09/1995)		(06/1980-08/1993)		(06/1982-09/1995)	
	Price index	Product evaluations (n=232)	Price index	Product evaluations upright freezers (n=136)	Price index	Product evaluations chest-type freezers (n=75)
C	4.59	6.53	4.50	6.47	4.53	6.66
t-statistic	1283.0	203.8	1188.3	151.3	1303.7	230.8
TIME	0.000958	0.002439	0.000843	0.003375	0.000826	0.001080
t-statistic	28.9	7.2	20.3	6.0	21.9	3.4
adj. R^2	0.82	0.18	0.72	0.21	0.75	0.14
Change in prices (in % p.a.)	+ 1.2	+ 3.0	+ 1.0	+ 4.1	+ 1.0	+ 1.3

close to the prices surveyed for inflation measurement (Table 29). Not only are chest-type freezers generally less expensive than upright freezers, they also exhibit a different price trend prior to quality adjustment (Table 32). Whereas the price of the chest-type freezers rose at an annual average of less than 1 ½ %, the price of upright freezers went up by approximately 4 % according to the product tests. This discrepancy is likely to be mainly attributable to test no. 10 which tested upright freezers with a very large interior volume and a correspondingly high price.

Major price-determining product characteristics of freezers (Table 33) are: interior volume, consumption of electricity, temperature stability following a power failure, and various equipment features, such as interior or exterior thermometers and the type of alarm in the event of power failure. The interior fittings of the freezers with compartments and drawers are likely to be another factor that is relevant to the buying decision. However, information on the interior fittings is, firstly, incomplete and, secondly, several approximative estimates failed. Some readers will regret that what is undoubtedly a major variable relevant to quality - the maximum freezing power - is missing from the list of price-relevant quality features. However, no consistent data on this feature were available over a longer period, either.

As with refrigerators, the problem of CFCs has arisen for freezers, too, since the late eighties; in contrast to refrigerators, however, it took longer for CFC-free appliances to become available on the market in large numbers. Only test 12 covers a few appliances

Table 33: Price-determining characteristics of freezers

Variable	
UP TO DATE	Dummy=1 for model continuing to be sold with an unaltered specification.
UPRIGHT	Dummy=1 for upright freezers.
BUILT-IN	Dummy=1 for appliances that can be fitted.
DEFROST	Dummy=1 for appliances with automatic defrost.
AVIS	Dummy=1 for visual alarm in the event of power failure.
AACOU	Dummy=1 for acoustic alarm in case of power failure.
THE	Dummy=1 for exterior thermometer.
THI	Dummy=1 for interior thermometer.
VOL	Interior volume (in litres).
RISE	Rise in temperature from - 18°C to - 9°C in the event of power failure (in hours).
ENERGY	Consumption of electricity (in kwh per 24 hours).

without CFCs; all appliances from test 10 onwards are to be regarded as models with a reduced CFCs content. However, in contrast to refrigerators, CFC dummies were not included owing to the scant information available. Accordingly, in interpreting of the following estimates it has to be borne in mind that an adequate inclusion of the elimination of CFCs from production would have made the price trend appear in a more favourable light.

Overall, the estimates yielded the following results:

- Adjusting the estimates to the data worked quite well for the sample overall (Table 34) and for the upright freezers (Table 35). In the vast majority of cases, the coefficients have the expected signs and are statistically significant at a high level to be greater than zero. This also applies to the dating of the products. The situation is different in respect of chest-type freezers (Table 36) where the specification with the fixed percentage price change led to less satisfactory results.
- It is quite remarkable that brand effects play scarcely any role with freezers; specifications of the estimates containing statistically significant brand dummies were found only for the large, overall sample. However, including the manufacturers' brand names does not have any impact on the results.
- Even after adjustment for quality there are marked differences between the price trends of chest-type freezers (Table 37) and of upright freezers (Table 35). The true rate of price increases is much lower here than in the Consumer Price Index. Thus, by choosing the specification "upright freezers", the Federal Statistical Office is likely to be capturing a market segment with above-average price increases.

- According to the product tests, the quality-adjusted rate of price increases for the overall sample (chest-type freezers and upright freezers) corresponds almost exactly to the average change in the price index (Table 34). However, it would probably be distinctly lower if CFCs had been adequately taken into account.
- Estimating flexible rates of price increases with a polynomial (Table 37) leads to results which are similar to those obtained for refrigerators (Chart 13): during the period of comparatively low rates of price increases in the mid-eighties, the bias would thus have been quite large, whereas it would have been negative in the early nineties when the switch to CFC-free appliances took place.

According to these estimates - which must nevertheless be interpreted with some caution owing to the CFC problem - the quality bias for freezers would be approximately nil on average. In the case of upright freezers, and thus of the appliances matching the specification in the Consumer Price Index, there is, on average, a significant negative bias in the rate of price increase. However, this is likely to have been mainly due to the fact that it was not possible to take into account the advances made in the elimination of CFCs and that the coefficient of the TIME variable is distorted upwards as a result. Here, though, the previously observed pattern is again apparent, i.e. that the bias is positive in times of stable or slightly increasing prices whereas it may also be negative given moderate rates of inflation. If it were possible to capture the increasing elimination of CFCs with sufficient accuracy, the result would probably change insofar as the negative bias would be smaller at the beginning of the nineties.

Table 34: Quality adjusted price changes of freezers

(6/80-9/95)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	6	6	6
C	-127.74	5.41	2.38	-181.57	5.33	2.3
t-statistic	-2.37	58.99	11.15	-3.21	55.55	10.5
UP TO DATE	-34.98	-0.06	-0.06	-35.67	-0.06	-0.06
t-statistic	-2.92	-3.61	-3.8	-2.97	-3.34	-3.6
UPRIGHT	338.93	0.44	0.38	343.96	0.45	0.39
t-statistic	12.91	14.01	13.2	12.72	13.96	12.8
BUILT-IN	235.69	0.35	0.36	260.78	0.38	0.38
t-statistic	9.03	11.10	11.2	9.33	11.47	11.4
DEFROST	452.65	0.35	0.38	461.13	0.35	0.38
t-statistic	6.57	11.38	11.8	6.82	9.68	12.1
AVIS	61.86	0.09	0.10	70.08	0.11	0.10
t-statistic	1.86	1.43	1.8	2.78	1.88	2.1
AACOU	57.97	0.07	0.07	45.22	0.05	0.05
t-statistic	3.70	3.44	3.4	2.57	2.04	2.1
THE	86.92	0.11	0.10	82.59	0.11	0.10
t-statistic	4.85	4.47	4.6	5.15	4.71	4.9
THI	44.43	0.07	0.06	28.75	0.06	0.05
t-statistic	3.10	3.06	2.9	2.08	2.69	2.5
VOL	3.22	0.004	0.71	3.15	0.004	0.70
t-statistic	19.10	21.76	20.0	17.85	21.20	18.7
RISE	2.19	0.003	0.06	30.9	0.004	0.09
t-statistic	2.31	2.35	1.9	2.93	2.80	2.4
ENERGY	-100.51	-0.14	-0.20	-80.59	-0.11	-0.16
t-statistic	4.08	3.73	-4.5	-3.03	-2.76	-3.6
TIME	0.001141	0.001109	0.001020	0.001096	0.001068	0.000996
t-statistic	4.52	4.54	4.2	4.50	4.58	4.3
n	232	232	232	232	232	232
adj. R^2	0.85	0.84	0.85	0.87	0.85	0.86
SE	0.11	0.12	0.11	0.11	0.12	0.11
Quality-adjusted price change (in % p.a.)	+ 1.4	+ 1.3	+ 1.2	+ 1.3	+ 1.3	+ 1.2
Bias (in percentage point p.a.)	- 0.2	- 0.1	0.0	- 0.1	- 0.1	0.0

Table 35: Quality-adjusted price changes of upright freezers

(6/80-8/93)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	3	not significant	not significant
C	187.68	5.80	2.93	153.29	-	-
t-statistic	4.30	71.28	12.8	3.48	-	-
UP TO DATE	-34.30	-0.06	-0.07	-24.14	-	-
t-statistic	-2.48	-2.78	-3.5	-1.68	-	-
DEFROST	402.01	0.32	0.37	415.65	-	-
t-statistic	5.94	10.19	11.7	5.41	-	-
AVIS	48.10	0.07	0.07	66.71	-	-
t-statistic	1.47	1.14	1.1	2.65	-	-
AACOU	82.77	0.09	0.09	83.91	-	-
t-statistic	3.53	2.96	3.0	3.52	-	-
THE	82.87	0.13	0.13	83.71	-	-
t-statistic	4.12	4.10	4.5	4.77	-	-
THI	50.76	0.10	0.10	42.16	-	-
t-statistic	2.60	3.33	3.6	2.44	-	-
VOL	50.75	0.004	0.71	3.09	-	-
t-statistic	15.67	19.10	17.6	15.36	-	-
RISE	2.35	0.003	-0.004	2.67	-	-
t-statistic	1.87	1.79	-0.1	2.04	-	-
ENERGY	-75.40	-0.12	-0.27	-75.36	-	-
t-statistic	-2.96	-2.78	-4.1	-3.09	-	-
TIME	0.001451	0.001294	0.001484	0.001305	-	-
t-statistic	4.30	4.10	4.5	3.88	-	-
n	136	136	136	136	-	-
adj. R^2	0.90	0.89	0.90	0.91	-	-
SE	0.11	0.12	0.11	0.11	-	-
Quality-adjusted price change (in % p.a.)	+ 1.8	+ 1.6	+ 1.8	+ 1.6	-	-
Bias (in percentage point p.a.)	- 0.8	- 0.6	- 0.8	- 0.6	-	-

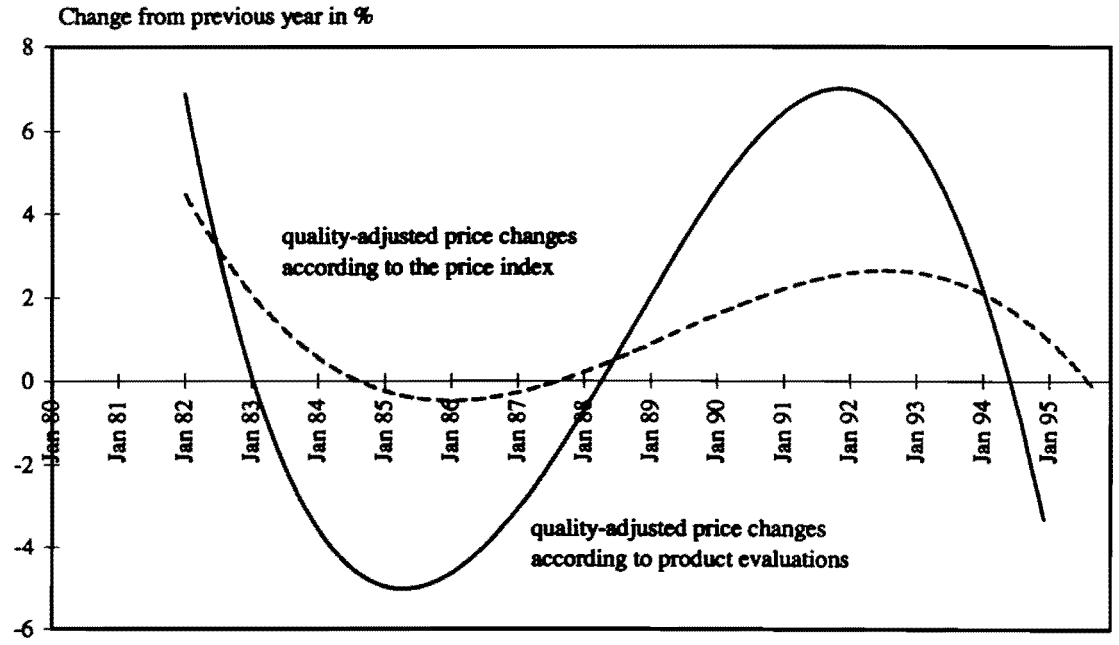
Table 36: Quality-adjusted price changes of chest-type freezers

(6/82-9/95)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	not significant	not significant	not significant
C	351.86	6.16	2.66	-	-	-
t-statistic	2.72	31.45	3.2	-	-	-
UP TO DATE	-42.83	-0.06	-0.06	-	-	-
t-statistic	-1.59	-1.74	-1.8	-	-	-
AACOU	32.90	0.04	0.04	-	-	-
t-statistic	1.28	1.25	1.3	-	-	-
THE	63.18	0.07	0.07	-	-	-
t-statistic	1.56	1.52	1.6	-	-	-
THI	11.19	0.01	0.01	-	-	-
t-statistic	0.42	0.34	0.3	-	-	-
VOL	2.50	0.003	0.71	-	-	-
t-statistic	5.57	5.02	5.0	-	-	-
RISE	0.52	0.001	0.02	-	-	-
t-statistic	0.33	4.34	0.2	-	-	-
ENERGY	-185.64	-0.22	-0.24	-	-	-
t-statistic	-3.66	-3.15	-2.8	-	-	-
TIME	0.000528	0.000536	0.000554	-	-	-
t-statistic	1.31	1.33	1.3	-	-	-
n	75	75	75	-	-	-
adj. R^2	0.57	0.52	0.50	-	-	-
SE	0.11	0.11	0.11	-	-	-
Quality-adjusted price change (in % p.a.)	+ 0.6	+ 0.6	+ 0.6	-	-	-
Bias (in percentage point p.a.)	0.4	0.4	0.4	-	-	-

Table 37: Flexible price changes of freezers

(11/79-11/96)	Price index	Product evaluations (semi-log; 11 characteristics)
C	4.42	5.50
t-statistic	2132.4	68.0
TIME^1	0.008211	0.019495
t-statistic	52.0	8.7
TIME^2	-0.000153	-0.000479
t-statistic	-43.4	-8.9
TIME^3	$1.12*10^{-06}$	$3.93*10^{-06}$
t-statistic	38.7	8.5
TIME^4	$-2.65*10^{-09}$	$-1.01*10^{-08}$
t-statistic	-33.8	-7.8
adj. R^2	0.99	0.90
SE	0.01	0.10

Chart 13: Time-dependent price changes of freezers



4. Extrapolation of the Quality Change Bias

> "In a period of comparatively substantial price stability, however, the bias is relatively more significant than in times in which prices show a considerable rise."
> Horstmann (1963)

As was the case with the product substitution bias, the QUESTION OF GENERALISING THE VARIOUS PARTIAL RESULTS arises. Boskin and his colleagues on the ADVISORY COMMISSION TO STUDY THE CONSUMER PRICE INDEX (1996) collected the results of a large number of studies for subindices of the CPI and estimated the deviations of ideal indices from the published series in a very detailed manner using back-of-the-envelope calculations. It was not possible to do so in the present study, since no up-to-date detailed studies exist for Germany.

For that reason, another course had to be followed for generalisation. This is essentially based on an extended version of the SIMPLE MODEL FOR ANALYSING THE RULES GOVERNING THE QUALITY ADJUSTMENT OF PRICES, as it was presented in section IV.2.d (p. 47 ff.). Given the long and sometimes arduous stretch of ground that has been covered in the interim, at this point I would like to summarise the results obtained so far:

- First, the METHODS APPLIED BY THE FEDERAL STATISTICAL OFFICE FOR THE QUALITY ADJUSTMENT OF PRICES were analysed. This analysis essentially yielded TWO HYPOTHESES ON THE QUALITY CHANGE BIAS FOR INDIVIDUAL GOODS (see p. 52):
  - For percentage changes of prices around the rate of the product-specific advance in quality, the bias should be small.
  - In the case of smaller or larger price increases that are more remote from the product-specific advance in quality, the bias will be large and positive.
- In the three case studies, these hypotheses were tested against the data in a two-fold manner:
  - First, the UNADJUSTED AVERAGE PRICES from the price statistics were compared with the QUALITY-ADJUSTED PRICE INDEX. The difference between the two rates of change approximately corresponds to the average quality adjustment made by the price statisticians. Indeed, during the period under review, adjustments of prices were principally made in times of higher rates of inflation, whereas the implicit change in

quality was very low or, in some cases, even negative in the sub-periods of declining or stagnating prices.

- Moreover, HEDONIC PRICE EQUATIONS were estimated as a supplement. The prices were regressed on product characteristics and a time polynomial in order to calculate the time-dependent bias. According to these regressions, the quality change bias occurs principally in times of low or negative rates of price change. With higher price increases, however, the bias is much smaller, and sometimes even below zero.

All this initially applies only to individual goods; what still remains to be examined is the impact of these measurement problems on the OVERALL ACCURACY OF INFLATION MEASUREMENT. If a positive bias for one good offsets a negative bias for another, it would not be possible to interpret the subindices for individual goods without qualification, but this would be unimportant in terms of measuring overall inflation. Hence, the total bias is mainly likely to depend on the HETEROGENEITY OF THE TRENDS IN THE PRICES AND QUALITY OF INDIVIDUAL GOODS.

First, the question of the MAXIMUM QUALITY BIAS arises. If price statisticians correctly recognise the advance in quality and follow the instructions of the Federal Statistical Office, the total quality bias should not be greater than the growth in quality in the economy as a whole. Since we have so far been unable to observe an advance in quality occurring at the expense of the quantities consumed, the growth in quality is likely to be confined in the long term by the growth in productivity and in real income. On a multi-year average, the OVERALL GAIN IN PRODUCTIVITY AND IN REAL INCOME WAS AROUND 2 % PER ANNUM.[1] Thus, the total quality bias is unlikely to be greater than 2 percentage points per annum, either. Assuming that only 50 % of the growth in real income is spend on improvements in quality - which the author believes to be more plausible - 1 PERCENTAGE POINT PER ANNUM WOULD BE THE CEILING OF THE MEASUREMENT BIAS.

To estimate the quality change bias contained in the Consumer Price Index, further MODEL CALCULATIONS are therefore undertaken which initially analyse only two, and later four goods with differing trends in productivity and quality. In each case, the product-specific

[1] However, because prices being inadequately adjusted for changes in quality, figures for the gain in productivity may itself be distorted downwards, which means that the true productivity gain might be higher.

rates of progress for productivity and quality are selected to yield an OVERALL PRODUCTIVITY GAIN OF 2 % AND A GROWTH IN QUALITY OF 1 % PER ANNUM.[1]

These model calculations work on the assumption that price statisticians recognise the differences in quality and assess them correctly. Furthermore, the direct procedures applied by the Federal Statistical Office (see p. 45 ff.) should be used for adjusting the base prices to eliminate changes in quality. It is also still assumed that model changes customarily occur once a year and that price adjustments are undertaken at the same time, owing to the menu costs arising when prices are changed.

The model calculations are based on a simple model of price formation. Let p_i be the price of the good i of a constant quality, w the wage rate, m_i the mark-up rate and q_i a measure of labour productivity. Then the following should apply:

$$(18) \quad p_i = m_i \frac{w}{q_i}$$

For simplification, it is also assumed that the mark-up is constant.[2] Equation (18) can then be written in continuous growth rates as follows:

$$(19) \quad \psi_i = \omega - \varphi_i$$

with ψ for the price change, ω for the rate of wage increases, and φ as the rate of change in labour productivity.

How is this extremely simple model to be modified if quality changes are to be admitted? In reality, PROCESS INNOVATIONS (i.e. cost reductions due to improvements in the production process) and PRODUCT INNOVATIONS (i.e. improved products) go hand in hand. New products are only made possible by new production technologies. These two activities - i.e. cutting production costs and improved product design - are to be notionally separated below, however. Solely efficient production, where - at a given point in time - higher product quality can be produced only at matching additional cost, is analysed.[3] When a

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1 This calibration could result in the overall quality bias being overestimated, since part of the improvement in quality overall is reflected in a different pattern of consumption. When eating habits improve, this could mean either more beef and less pork (= changed basket of goods), or better beef or pork (=improvement in quality).

2 The following considerations can also be applied without major difficulties to the case of variable mark-up.

3 See, however, Hulton (1997) for a discussion of quality change with non-proportional cost increases.

product moves into a higher market segment over time its price will be adjusted if the COSTS SAVED BY TECHNOLOGICAL PROGRESS IN PRODUCTION are smaller (or greater) than the ADDITIONAL COSTS INCURRED BY THE NEW, BETTER SPECIFICATION. With ϕ symbolising the growth in quality. instead of (19) the following equation will apply to the CHANGE IN MARKET PRICES:

(20) $\psi_i = \omega - \varphi_i + \phi_i$

The TRUE CHANGE IN PRICE corresponds to the difference between the change in market price and the change in quality and thus also to the difference between the growth of wages and productivity:

(21) $\pi_i = \psi_i - \phi_i = \omega - \varphi_i + \phi_i - \phi_i = \omega - \varphi_i$

In the following MODEL CALCULATIONS FOR THE QUALITY CHANGE BIAS, the detailed procedure described below is employed for each individual good:

- First, a GROWTH RATE OF WAGES is assumed.
- From this, the RATE OF PRICE CHANGE is calculated assuming a given growth rate of productivity.
- A PERCENTAGE CHANGE IN MARKET PRICES is obtained on the basis of an assumed change in quality.
- Assuming an absolute price for the base period, the MONETARY VALUE OF THE CHANGE IN QUALITY and of the TRUE PRICE CHANGE can then be calculated.
- The generalising rules of the Federal Statistical Office are then applied to these data. If called for by these rules, THE BASE PRICE IS ADJUSTED accordingly.
- Finally, index figures for the QUALITY-ADJUSTED PRICE TREND are calculated as the quotient of the market prices and the adjusted base prices.
- The quotient of the index figures for the quality-adjusted prices and the true change in prices yields an INDEX FIGURE FOR THE BIAS. If this quality adjusted price index rises faster than is consistent with the true rate of price increase, the bias is greater than zero.

The first model calculation is restricted to two goods; for the first good A the advance in productivity is rated at 4 %, the advance in quality at 2 % per annum. In the case of good B, however, productivity and quality are to remain unchanged. This calibration is based on the following observations: the sectoral rates of productivity growth are spread according to a

fixed pattern on average. They are at their greatest in agricultural and industrial production, they are comparatively small in the services sector. Even though there are examples illustrating the contrary, the advance in quality is often closely linked to the advance in productivity (expensive PRODUCT INNOVATIONS in connection with cost-lowering PROCESS INNOVATIONS). Hence, improvements in quality are likely to occur comparatively frequently in the case of many manufactured products, whereas they are likely to be less common in the services sector.[1] Thus, good A represents manufactured products, good B stands for services.

First, true and quality-adjusted percentage changes of prices and the corresponding index figures are calculated for good A. For good B, there is no advance in quality and therefore no difference between the index figures for true and for quality-adjusted changes in prices. Then, an OVERALL (QUALITY-ADJUSTED) RATE OF INFLATION can be calculated for the two goods. In this calculation it is assumed that the entire budget is distributed equally between both goods in the initial period. As in the official Consumer Price Index, the average rate of price increases is determined through a Laspeyres index. On these assumptions - compared with chart 4 for one good (p. 51) - the range of a comparatively low measurement bias shifts distinctly to the right (Chart 14). This suggests that the bias tends to be low if the true rate of inflation is between 0.5 % and 4.5 %.

For the SECOND MODEL CALCULATION, the product range is extended further. On the one hand, it would be sensible to add HIGH-TECH PRODUCTS WITH HIGH RATES PRODUCTIVITY AND QUALITY GROWTH to the product range. Owing to their particular price trends such goods would display either decreases in prices or - in comparison with the advance in quality - only minor price increases, so that the quality change bias would be positive throughout (even though it would probably decline slowly after having reached a given threshold value).[2]

On the other hand, it is repeatedly emphasised that DETERIORATIONS IN QUALITY exist, too. The main candidates for this are simple services without any advance in productivity which therefore become increasingly more expensive in comparison with other products. It is possible that consumers resort to less sophisticated qualities as a response to the change

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[1] This applies, above all, to simple services; in the case of knowledge-intensive services, such as medical services, the advance in quality may also be very large.

[2] For these products the assumption that only one price adjustment takes place per year might distort the estimated bias upwards.

Chart 14: The overall quality change bias depending on the true rate of inflation (1st model calculation: two goods, on average 1 % growth of quality)

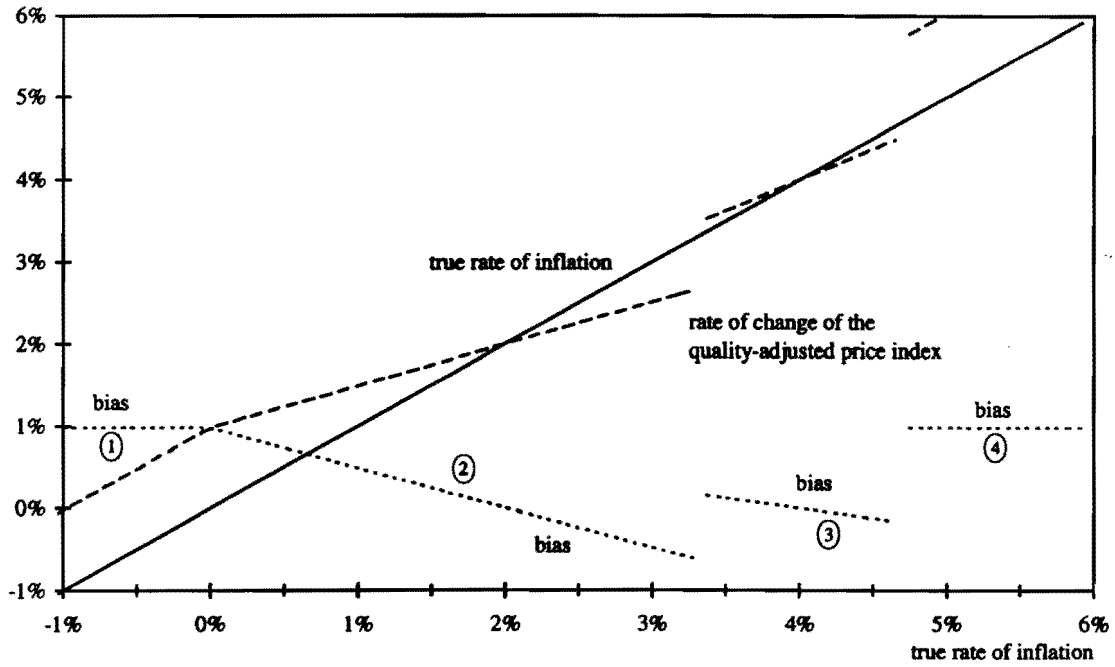

Chart 15: The overall quality change bias depending on the true rate of inflation (2nd model calculation: four goods, on average 1 % growth in quality)

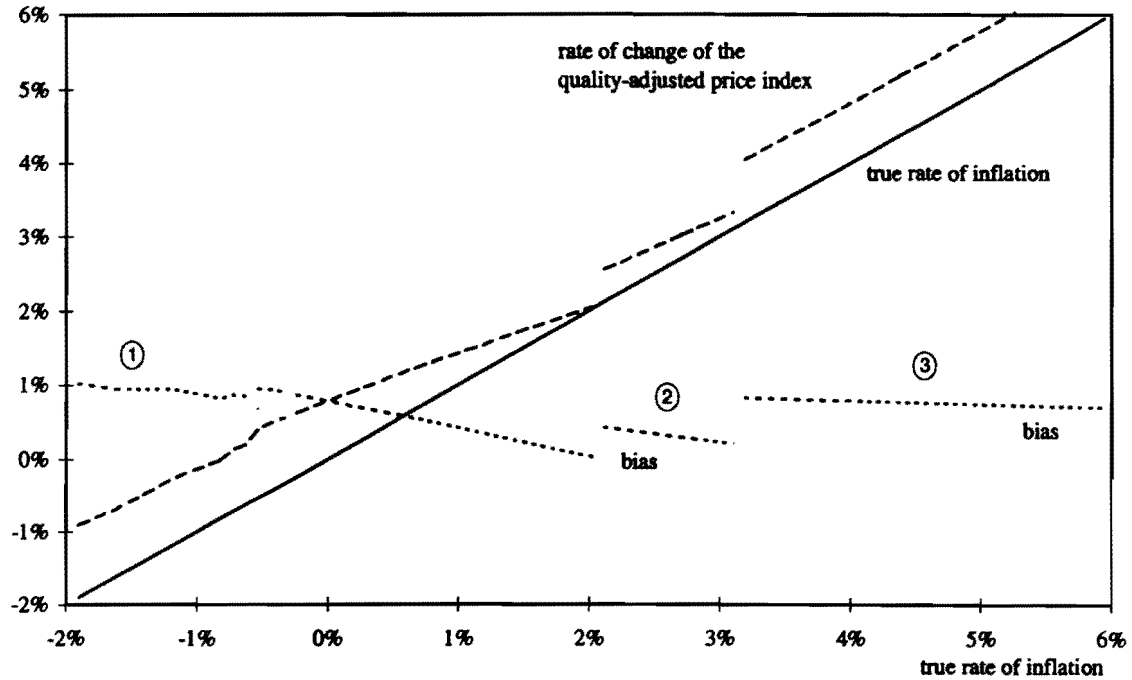

Table 38: Calibration of the 2nd model calculation on the quality change bias

	Good A	Good B	Good C	Good D
Share in expenditure (in %)	5	35	35	25
Productivity growth (in % p.a.)	12	3	1	0
Quality growth (in % p.a.)	9	1.5	0.25	-0.3

in relative prices. The author himself is not convinced by this argument, however, and it is also difficult to find examples of a deterioration in quality in the services sector except in isolated cases. However, one major example of gradual reductions in quality are DWELLINGS which deteriorate over time.[1] Given rising rents, such reductions in the standard of housing are not taken into account according to the instructions of the Federal Statistical Office, resulting in the rate of rent increase being understated.[2] In a overall approach, this negative quality change bias could at least partly offset any potential positive measurement biases in the case of manufactured products. For that reason, decreases in quality, too, are to be taken into account in the model calculation below. Specifically, the calibration stated in table 38 is applied.

For these four representative goods, true price changes and market price changes, as well as the respective quality-adjusted price index, were again calculated according to the method described above. The results are shown in Chart 15. Compared with the model calculation involving two goods (Chart 14), the following deviations may be observed:

- The overall quality change bias is now positive throughout because of the high-tech product.
- The negative bias in the case of dwellings diminishes the bias as a whole.
- The curve of the price index calculated according to the generalising rules of the Federal Statistical Offices is smoother throughout owing to the greater heterogeneity of the trends in productivity and quality. Although there are still some discontinuities, the jumps themselves have become smaller.

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1 Randolph (1988) estimates the wear-induced loss in the quality of dwellings in the United States to be 0.3 % to 0.4 % per annum.

2 Notwithstanding the wear and tear of the housing stock, there can be no doubt that the average quality of housing has increased significantly over the past few years; this is mainly due to new buildings which are better fitted in most cases, as well as to renovation of the existing housing stock. If such dwellings are included in price monitoring, the difference between the rents and the stock ought to be extracted as a difference in quality.

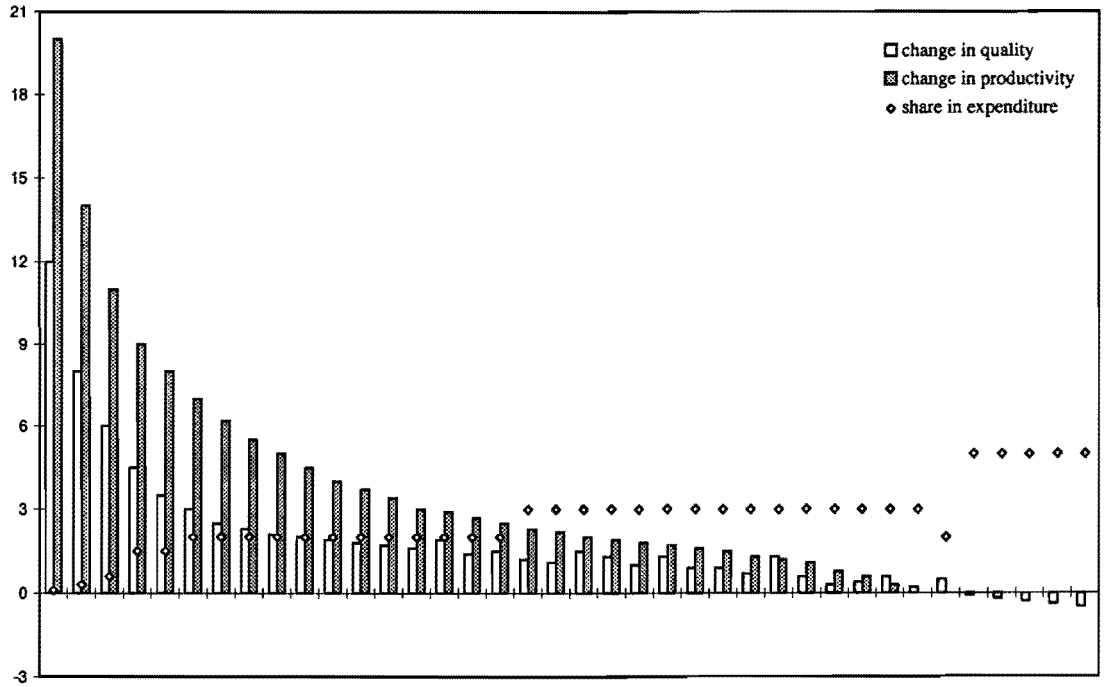
Up to now, the quality change bias has been represented as a function of the true rate of inflation, which cannot, however, be directly observed. In reality, one sees only the prices of individual products and the price indices that are published by the statistical offices. Therefore the RELATIONSHIP BETWEEN OF THE BIAS AND THE PUBLISHED RATE OF INFLATION is of particular interest. Such a representation would be of little illustrative value for the model calculations presented so far, since the graph of the measurement bias would display gaps corresponding to the discontinuities of the change in the price index between the areas ① and ②, as well as between the areas ② and ③ shown in chart 15.

Therefore, a THIRD MODEL CALCULATION was undertaken, for which the product range was further extended. The calibration is shown in detail in chart 16, with the goods being plotted on the horizontal axis and the budget shares as well the percentage changes in productivity and quality on the vertical axis. Besides high-tech products, there are thus also manufactured products with medium trends in productivity and quality as well as goods with only slight increases in productivity (services), and goods with a declining product quality (dwellings). Overall, the calibration was selected in a way that, in the author's view, approximately captures the reality. Moreover, in further model calculations, which are not listed here, similar but nevertheless deviating assumptions were included; although this had some effects on the results in individual cases, they essentially remained unaffected.

In this calibration the bias is comparatively small (< ½ percentage point p.a.) in the range of moderate rates of inflation between ½ % and 2 ½ % p.a.(Chart 17), but it is greater than the average bias in the model calculation with only four goods. This is mainly attributable to the fact that the range of heterogeneous price and quality trends is filled up more densely. At a recorded rate of inflation of less than ½ % p.a., the bias quite rapidly approaches its maximum value of around one percentage point p.a.; if inflation is higher, it rises slowly.

The easiest way to see how this result is obtained is to take a look at Chart 18, in which the bias for individual goods is represented as a function of the overall true rate of inflation. Initially, the goods displaying high rates of progress in quality and productivity contribute to a high overall bias. In the case of goods with lower rates of progress, the measurement bias, in succession, declines rapidly, becomes negative for a short while, then rises again, declines once more, and finally increases again to the maximum level.

Chart 16: Assumptions of the third model calculation



Owing to the heterogeneity of the trends in productivity and quality, at certain inflation rates the bias stands in the negative range only for a small number of goods at any given time; however, for the majority of goods the rate of price increase is overstated. At higher rates of inflation the bias retains its maximum value for goods with moderate advances in quality and productivity; however, the decreasing bias in the case of high-tech products ensures that there is initially only a moderate rise in the measurement bias. It is only at even higher rates of inflation that the bias reaches its maximum value again. Although dwellings display a negative measurement bias over almost the entire range of rates of inflation discussed in this study, the small size of this bias means that they it reduce the overall bias only by less than one-tenth despite their high share in expenditure.

On account of this and other model calculations, which are not given here, it seems appropriate to make the following distinction:

- PRICE DECREASES OR VERY LOW RATE OF INFLATION: Improvements in the quality of manufactured products and of food are often likely to be linked to price decreases or to stable prices. In these cases, the prices of new models are frequently not adjusted for improvements in quality. On the whole, the true rate of inflation is likely to be significantly overstated given very low rates of price increases or deflation.

Chart 17: The overall quality change bias depending on the recorded rate of inflation

(3rd model calculation: 38 goods, on average 1 % growth in quality)

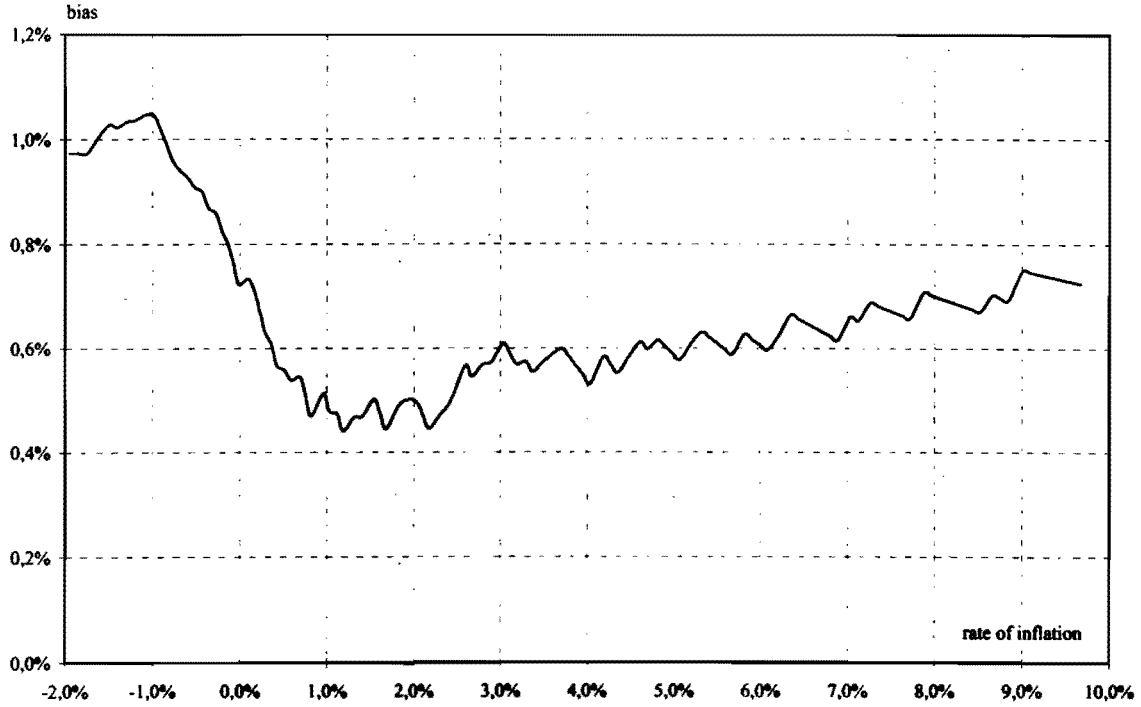
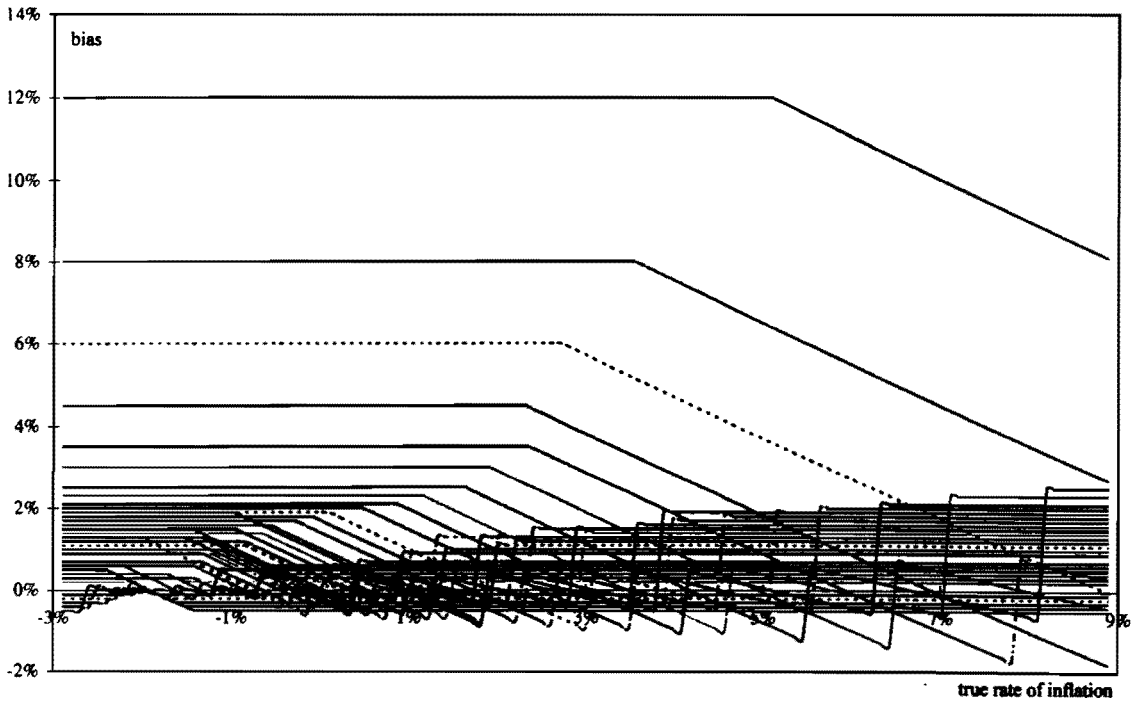


Chart 18: The quality change bias of individual goods depending on the true rate of inflation (3rd model calculation: 38 goods, on average 1 % growth in quality)



- LOW TO MODERATE RATE OF INFLATION: Changes in quality are often linked to increases in prices which are not significantly higher than the value of the improvement in quality. On average, the true rate of inflation can be captured fairly accurately if the rules of the Federal Statistical Offices are applied correctly. However, the quality change bias will be positive over the entire range and might be approximately ½ percentage point if the average advance in quality is 1 % per annum.
- HIGH RATES OF INFLATION: In the vast majority of cases, changes in quality occur only in combination with major price increases. The quality improvements will often be small compared with the differences in price. In accordance with the rules of the Federal Statistical Office no quality adjustment is then made in most cases. If price statisticians adhere to these rules the rate of price increases will be sharply overstated. However, the possibility cannot be ruled out that, given higher price increases, price statisticians are more inclined to extract part of the increase for improvements in quality. Furthermore, the underlying assumption of the model calculations that prices are adjusted only if models change, may prove to be inaccurate if there are higher rates of price increases (see p. 52f). The bias would then be smaller than that resulting from the model calculations presented here.

These extrapolations are based on the assumption that the price statisticians of the statistical offices of the Länder apply the direct procedures prescribed by the Federal Statistical Office for adjusting prices for quality. However, the possibility cannot be ruled out that the method of chain-linking in overlapping periods is used quite often as well. This procedure, too, will generally result in the true rate of price increase being overstated when a new product variant squeezes the old model out of the market. In particular, the chaining method does not solve the specific problems of high-tech products either, the quality of which improves even if prices are decreasing.[1] According to studies by the French statistical office INSEE, a price index for personal computers calculated using the hedonic method decreases much faster than a price index compiled using the method of chain-linking in overlapping periods.[2] The results presented in this study are thus unlikely to change much if this form of chaining, too, is taken into account.

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1 See Nicholson (1967).

2 See Lequiller (1997).

V. The New Product Bias

1. Measurement Biases When New Goods Are Introduced

> "An attempt to introduce all innovations into an index as soon as they appear would clutter the index with the failures that never attain appreciable importance. On the other hand, if new products are introduced only when the old items are completely displaced, the index will become seriously obsolete and will fail to reflect the price movements of the "volume sellers" much of the time."
> Price Statistics Review Committee (1961)

Essentially, new goods raise two major questions for the measurement of inflation:

- How soon should new goods be taken into account when measuring inflation?
- How should new goods be integrated into a price index?

Economic theory provides fairly clear answers to both questions:

- New goods should be included in inflation measurement when they enter the market.
- The RESERVATION PRICE of new products (i.e. the notional price at which the quantity in demand would be equal to zero) should be included in the price index with the result that the increase in consumer's surplus arising from the new goods is adequately taken into account.[1]

However simple they may sound, neither answer is very helpful to price statisticians. As price statisticians - not least for reasons of cost - have to confine themselves to analysing price trends in a limited number of goods and services, new goods are usually not included in an index until they have established themselves in the market and have passed a certain sales threshold. However, there is then the risk that a macroeconomically relevant proportion of price reductions is not included in the measurement of inflation because new goods follow a typical PRODUCT LIFE CYCLE: as a rule, innovative products are initially pro-

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[1] See Hicks (1940), Rothbarth (1941), Fisher/Shell (1968). Estimating such reservation prices, however, is not an simple task even though Hausman (1997a) and (1997b) as well as Fisher/Griliches (1995) and Blow/Crawford (1997) have recently made some progress here. Nevertheless, applying a reservation price would only be of limited use in a Laspeyres index because, given a quantity of zero in the base period, the weight in the following periods would also be equivalent to zero.

duced in small quantities, which are used to test whether or not there is any demand for them at all. These early models are typically very expensive. With increasing market success - if that is the case - there is a changeover to mass production. Production is rationalised, and, as output rises, there is a dramatic fall in unit costs - partly as a result of learning curve effects. Also, more and more imitators appear with the result that pricing behaviour approaches that in a competitive market. Accordingly, the (relative) prices for product innovations decline substantially in this market phase. It is only after consumers have largely satisfied their initial requirements that the price trend slows down and conforms to the trend in similar products. Consequently, a price index based on old products alone overstates inflation.

When considering the inclusion of new products in a Laspeyres index, it is sensible to make a distinction between two cases:

- A NEW PRODUCT IS INCLUDED ALONG WITH OLD PRODUCTS in a basket of goods. If a new good is included with a small value weight in a Laspeyres index shortly after it has been put on the market, the early price fall will not be entirely lost when measuring inflation. Nevertheless, the particular price trend of the new product will not be adequately taken into account in the current measurement of inflation because its relative importance will be adjusted in line with the relative price trend. In other words, the relative importance of such a product declines in current inflation measurement owing to the particular price trend concerned, whereas the product typically gains in importance in terms of turnover in this market phase when compared with old products. However, the price trends of individual products should be included in terms of their relative importance to turnover when measuring inflation in order to give an adequate picture of aggregate inflation from the consumers' point of view; new products therefore ought actually to be given an increasing relative importance. The intertemporal price level comparison will thus be distorted upwards.
- An OLD PRODUCT IS REPLACED BY A NEW PRODUCT. This happens when the number of price representatives is to remain constant in order to limit the recording input. In that case the total expenditure for the new product and for the one it has replaced will be attributed to the new product as part of the representative weighting. Then, however, the particular price trend of the new product will be given too a high a weighting when inflation is measured, resulting in inflation being understated.[2]

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[2] See Rees (1961).

The problem of new goods cannot therefore be solved satisfactorily using a traditional Laspeyres with a basket of goods fixed over a period of several years.[3] Either a new product is not included until it has become well established on the market, with the result that the initial fall in price is not taken into account at all, or it is included relatively soon after its introduction into the market. In the latter case, however, it is included either with a relative importance that is falling for current inflation measurement (in contrast to its increasing importance in terms of turnover) and which is therefore too small (a new product alongside old products), or too large (a new product replaces an old price representative). This means that, owing to the particular price trend of new products, the measurement bias is, in principle, indeterminate in terms of its sign; in the case of a Laspeyres index with a basket of goods fixed over a period of several years, however, the problem of the non-inclusion of new products is likely to be predominant.

A solution to this problem might be found in an ANNUAL CHAIN-LINKING OF LASPEYRES INDICES.[4] It has emerged from the discussion of the substitution effect with a fixed selection of goods that the effort of annually rebasing a given selection of price representatives is unlikely to be worthwhile: firstly, discrepancies between a Laspeyres price index with a fixed base and a chain-linked Laspeyres price index over a ten-year period are not very great; secondly, calculating representative baskets of goods annually would call for very detailed surveys of consumption. With a view to new goods, this assessment would possibly have to be modified. For one thing, an annual chain-linking of Laspeyres indices might make it possible to take new products into consideration shortly after they have been put on the market; for another, it might perceptibly ease the weighting problem. As a rule, however, it would probably be virtually impossible to draw on consumption patterns in the immediately preceding period when preparing the price index for the following year, with the result that the weights would typically be two years old even given an annual chain-linking. Nevertheless, such a time-lag would, if anything, be welcome from another point of view since it would allow a careful selection of new or additional price representative to be made and would help to avoid the precipitate inclusion of "flops".

Even if the problems of recording goods and the weighting problem could be solved by chain-linking indices, the question would still remain as to how new products should be included in an index. As a rule, statistical offices incorporate the series of index figures for a new product into a new basket of goods in such a way that this does not influence the

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[3] See Shapiro/Wilcox (1996).

[4] See Hill (1988).

price level in the adjoining period but rather the recorded inflation in the following months. This means that either NEW GOODS ARE PLACED NEXT TO OLD GOODS or that THEY REPLACE THEM; they are not, for example, compared with them and a price difference commensurate with the difference in quality then being deducted.

This method may serve as an adequate approximation where new products represent close substitutes for existing products.[5] However, this is precisely what happens in the case of a QUALITY CHANGE, where, in line with normal price statistical practice, quality differences between the products are indeed to be eliminated for inflation measuring purposes (see page 35 ff.). In contrast to quality changes, new products in the strict sense of the term usually provide performance features in a new way and with a much more favourable price-performance ratio than old goods. For that reason, it would be particularly important for measuring inflation if the performance of new products were evaluated and compared with that of old products, as is the generally recognised practice in the case of a change in model (i.e. new products which are very similar to old ones and where the improvements in quality are therefore not so great). As examples of cost-lowering innovations where such a procedure would be possible and useful, Gordon (1993) cites pocket calculators (as opposed to old desk calculators) and video recorders (as opposed to the cinema), while the Advisory Commission To Study The Consumer Price Index (1996) cites comparisons of personal computers with text processing systems (with typewriters) and encyclopaedias on CD-ROM (with printed encyclopaedias).[6]

Actually, the corresponding loss in consumers´ surplus would have to be applied for products that are withdrawn from the market. As this does not happen either, traditional price indices understate the rate of inflation compared with an ideal price index. In growing economies, however, the range of products available continually expanding, which means that consumers' heterogeneous preferences or their desire for change are better served. Oulton (1995) mentions holiday travel as a particularly relevant example: if prices of (old and new) package tours remained constant, a conventional price index would show no change even if additional products were included in the basket of goods. Owing to the greater choice of holiday trips, however, their real value would rise. Much the same is true of the very much greater choice of foodstuffs now available; this is not taken into account either when inflation is measured.[7]

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5 See Shapiro/Wilcox (1996).

6 See also Burstein (1961).

7 See the Advisory Commission to Study the Consumer Price Index (1996) and Hausman (1997a).

The range of products will increase if rising income is accompanied by a growing demand for GREATER PRODUCT DIFFERENTIATION, whether this be the result of a desire for change or improved satisfaction of heterogeneous needs. However, an increase in product differentiation also has its price in the form of higher production and sales costs. If the range of products available is to meet market demand more satisfactorily, prices will therefore be higher than in the case of mass production of a small number of standard models. Price statistics are concerned only with the rise in prices, however. The potentially prosperity-enhancing effect of greater product variety is, however, not taken into consideration. Even though there is virtually no doubt at the abstract level about the importance of increasing product differentiation, there are still no comparatively simple methods available which would permit the estimation of a PRODUCT VARIETY BIAS.

2. New Products in the German Consumer Price Index

In the German price statistics new products in the strict sense of the term (as opposed to quality changes) are normally not taken into account until the INTRODUCTION OF A NEW BASE YEAR FOR PRICES. This conversion is preceded by a REVISION OF THE LIST OF GOODS ON WHICH DATA IS TO BE COLLECTED so that the prices of the new products can be ascertained for the period prior to the creation of the new basket of goods. This means that the prices of new goods are recorded for about four years before they are included in the calculation of the current rate of inflation.

The decision to include a new product in the list of goods on which data is to be collected is based on market observations conducted by the statistical offices, which likewise costs time. What is more, a product is not taken into account until it can be expected to have a LASTING MARKET SIGNIFICANCE. Accordingly, most new products are incorporated into the consumer price index only at a fairly late stage. In current inflation measurement, the time lag amounts to at least five years (one year's preparation and four years' lead time for the new basket of goods; see page 11 f.) although, as a rule, it tends to be more like 10 years.

According to the Federal Statistical Office, however, new goods which may be regarded as a FURTHER DEVELOPMENT OF A PRODUCT ALREADY INCLUDED IN THE BASKET OF GOODS should be included in the measurement of inflation when they have achieved greater importance in terms of turnover than a variant of the old product at one reporting unit. The Federal Statistical Office cites the example of "inline skates" as a new variant of the item "roller-skates". Prices are to be adjusted for any differences in quality when substituting the price representatives. The same simplified methods as in the case of QUALITY CHANGES are to be used in doing so. Accordingly, problems which are similar to those described for quality changes will arise here, too. Although relatively sharp price reductions when the product is first put on the market would not be included in this case either, the measurement bias would be less than if the product were taken into account later when the price index is rebased.

Table 39 contains data on new goods in the west German Consumer Price Index and their presence in households according to the CONTINUOUS FAMILY BUDGET SURVEYS. Whereas video cameras were included on all reasonable criteria at a fairly early stage in

Table 39: Selected new products in the Consumer Price Index

Item	Category	Takes place of ...	Included in current inflation measurement from ...	Presence in selected households in the year product first included in inflation measurement[1] (in %)			Included in basket of goods from base year	Relative importance in the first base year (in %)	Presence in selected households in first base year[1] (in %)		
				HH1	HH2	HH3			HH1	HH2	HH3
Videorecorder	Phono equipment (including video equipment)	Cine-film projector	04/1984	1,3	14,7	12,0	1980	0,056	-	-	-
Video camera	Phono equipment (including video equipment)	Cine-camera	09/1989	0,6	4,6	6,5	1985	0,016	-	1,1 (1986)	1,2 (1986)
Home computer (PC from 1992)	Photocopying equipment and other office equipment	-	09/1984	0,6	25,8	37,4	1980	0,004	-	14,0 (1986)	20,7 (1986)
Walkman	Phono equipment (including video equipment)	Cassette recorder	09/1989	-	-	-	1985	0,073	-	-	-
CD player	Phono equipment (including video equipment)	Record Player	(Replacement 1992)	-	-	-	1991	0,055	-	-	-
Microwave oven	Electric cookers and electric ovens	-	08/1995	24,1	64,5	59,5	1991	0,045	10,6	49,1	47,7

[1] Continuous Family Budget Surveys
HH 1: Two-person households of pensioners or recipients of social assistance.
HH 2: Four-person households of salary or wage earners with a middle income of a married sole earner.
HH 3: Four-person households of civil servants or salary earners with higher income.

inflation measurement, the picture seems less favourable in the case of home computers and PCs and, especially, for microwave ovens. CD players were ultimately included in the current index "at the last minute" in 1992 because it had become virtually impossible to obtain representative prices for traditional record players, which had been very rapidly displaced. Although a major new product, television games, was represented in the basket of goods in 1980 and 1985, it was excluded - without replacement - from the items surveyed for the price base year of 1991.

The implications of the late inclusion of a new product are shown in the following case study, using MICROWAVE OVENS as an illustration. Firstly, the bias should be particularly dramatic here because microwave ovens were taken into account in the price statistics extremely late by German standards. Secondly, Stiftung Warentest has regularly been testing microwave ovens since the early eighties so that information on retail prices is also available from this source.

3. Case Study No. 5: A New Price Index for "Electric Cookers and Electric Ovens"

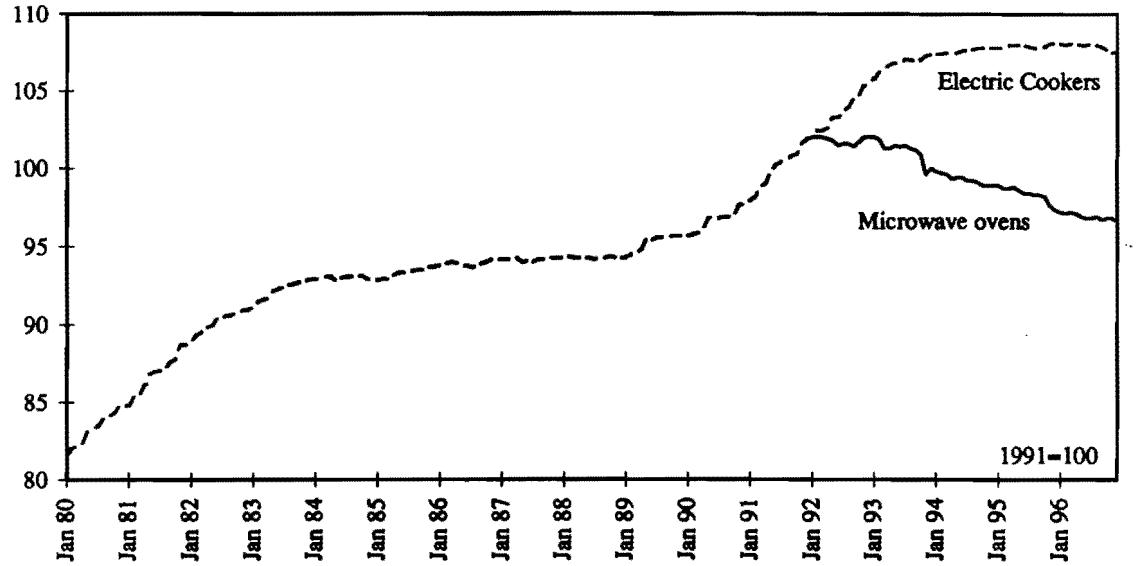
Microwave ovens are regarded as one of the most successful product innovations in the past 25 years. Initially, safety problems and an unfavourable ratio of external dimensions to internal capacity prevented them from becoming volume sellers; after these difficulties had been overcome, they quickly gained in market significance from the mid-eighties onwards in Germany, too. Nevertheless, they were not included in current inflation measurement until the summer of 1995 when the new index based on 1991 basket of goods was introduced.

In line with the representative weighting used in the German Consumer Price Index (see page 12 f.) expenditure on microwave ovens was assigned to the category "ELECTRIC COOKERS AND ELECTRIC OVENS". Until 1991 electric cookers had been the sole price representative for this category of expenditure. Microwave ovens were first purchased by west German households on a major scale in the mid-eighties; accordingly, the relative importance for electric cookers in the Consumer Price Index was increased by one-third (from 0.144 % to 0.198 %) in the 1985 basket of goods. With the introduction of a price representative for microwave ovens it was then reduced for the base year of 1991 to just over one-half of this (0.105 %). This "erroneous" allocation of expenditure on microwave ovens in the eighties would not have adversely affected the accuracy of the measurement of inflation if the price trend of electric ovens had been similar to that of microwave ovens.

This, however, was not the case. Chart 19 shows the index figures for the quality-adjusted price trend according to the official price statistics. While the prices of electric cookers move much in line with the price trends of other large electrical appliances, prices of microwave oven show a sharply falling trend at the beginning of the nineties (earlier data are not available in the consumer price statistics), suggesting that the rate of inflation was overstated in the eighties owing to the fact that microwave ovens were not included in the Consumer Price Index.

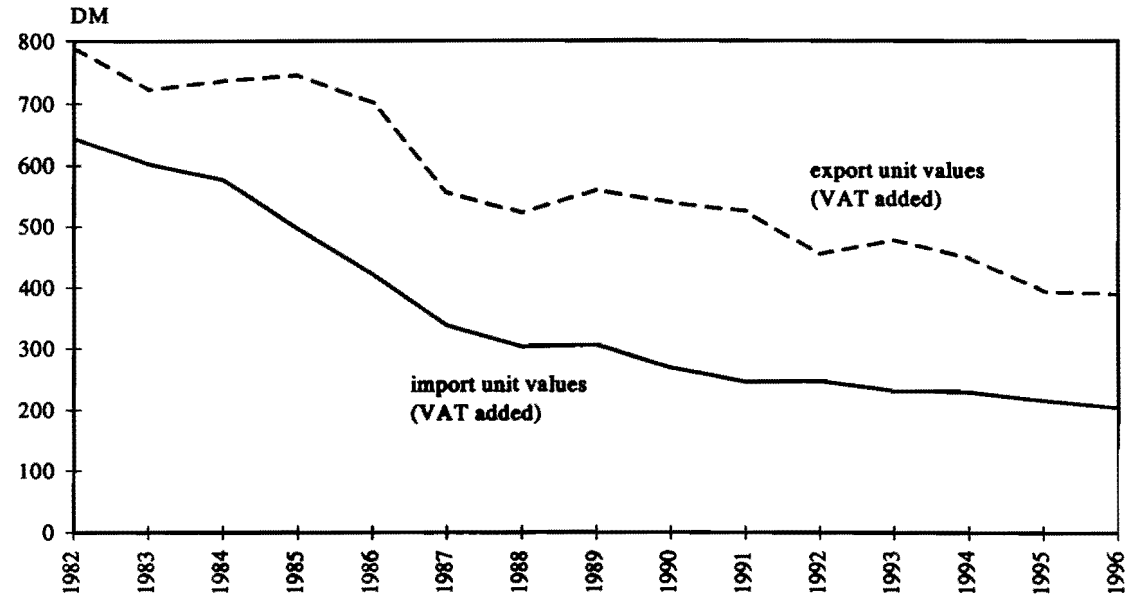
This conjecture is reinforced by a glance at the unit values for imports and exports of microwave ovens (Chart 20) which fell by one-third and one-half, respectively between 1982

Chart 19: Price trends of microwave ovens and electric cookers in the Consumer Price Index



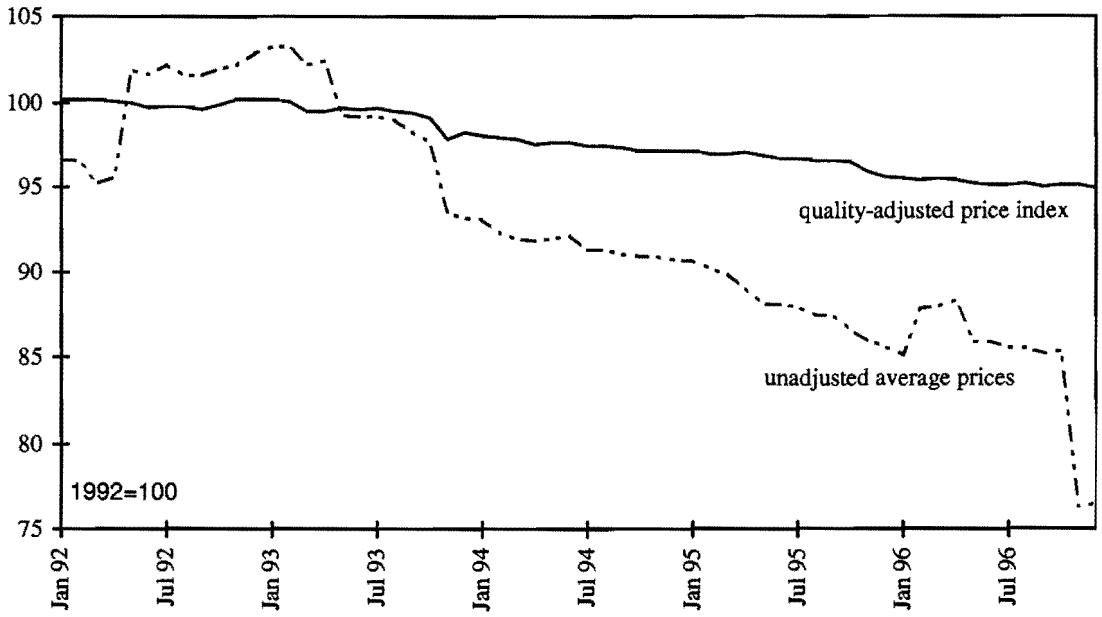
and 1996 (prices for earlier periods are not available).[8] Although this decline in unit values may also have been due to the fact that the appliances had become smaller and served less demanding segments of the market to a greater extent, the underlying trend does not indicate any increase in prices in the eighties.

Chart 20: Unit values for imports and exports of microwave ovens



[8] To improve the comparability of these figures with those in the consumer price statistics the import and export prices shown in the chart include the value added tax obtaining at the time.

Chart 21: Price trends of microwave ovens in the consumer price statistics



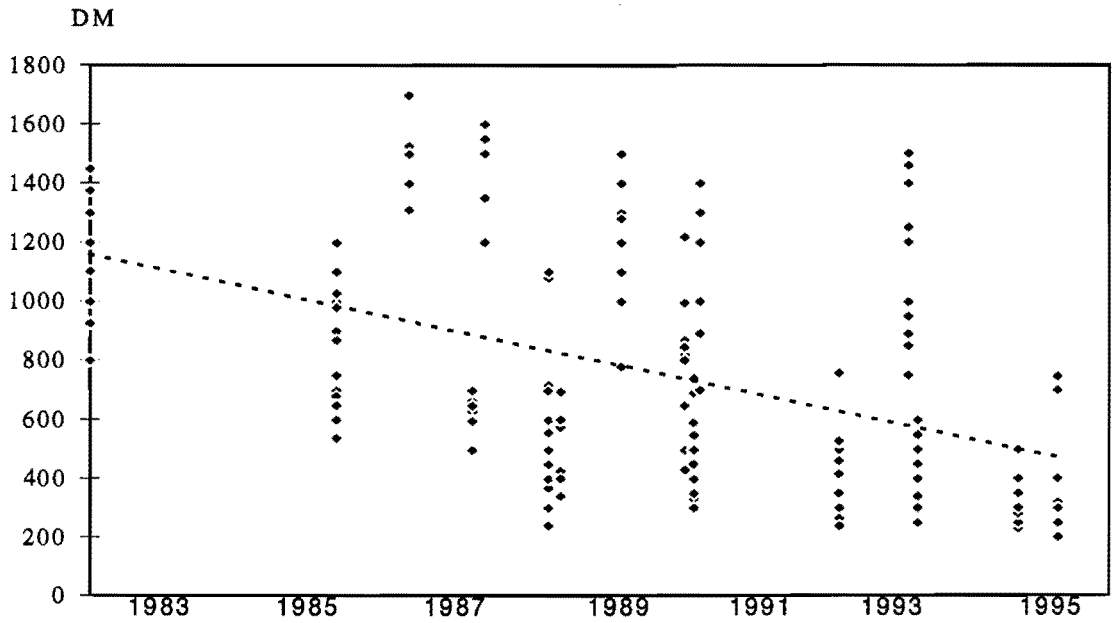
Import unit values (plus value added tax) have declined by an average of about 15 % since 1992. This is more or less in line with the trend in average prices in the consumer price statistics up to October 1996 (Chart 21) although these prices declined again by 10 percentage points, probably as a result of a change in specification. A significant part of the decline in the prices of microwave ovens was considered by price analysts to be in connection with a DETERIORATION IN QUALITY and was eliminated accordingly. At all events, the index figure in the consumer price index at the end of 1996 was no more than about 5 % below that of 1992!

This decline in quality was probably essentially due to the opening-up of new market segments. Whereas initially it was the socio-economic groups with greater purchasing power and a substantial urge to acquire the new product that were the buyers, significant sales figures could be achieved later only through selling to customers who were less prepared to pay the higher prices. Consequently, less sophisticated models probably gradually replaced medium category models as the appliances having the largest sales volume. This change was accompanied by fairly sharp price reductions, which were more or less completely regarded as quality-related and extracted. However, a point that may have been overlooked here is that even simpler appliances may be considerably more efficient nowadays than models in more sophisticated market segments were previously.

Table 40: Tests of microwave oven carried out by Stiftung Warentest

Test no.	Publication	Prices	Type	Number of models	Average price (DM)	Average power (watts)	Average capacity (litres)
1	7/82	3/82	Single-function appliances	13	1156	619	26
2	12/85	7-8/85	Single-function appliances	22	858	642	26
3	12/86	7-8/86	Combined-function appliances	8	1465	640	24
4	12/87	6/87	Compact appliances	14	599	578	16
5	Update of 12/86	8/87	Combined-function appliances	7	1421	631	24
6	12/88	6-7/88	Compact appliances	19	543	561	16
7	Update of 12/87	8-9/88	Compact appliances	7	519	567	14
8	12/89	6-7/89	Combined-function appliances	13	1255	646	24
9	5/90	10-11/89	Single-function appliances	13	815	719	27
10	12/90	6-7/90	Compact appliances	18	452	625	16
11	Update of 12/89	7-8/90	Combined-function appliances	13	1130	646	24
12	12/92	6-7/92	Compact appliances	13	390	658	15
13	10/93	6/93	Combined-function appliances	17	1105	735	29
14	12/93	7-8/93	Single-function appliances	16	436	819	19
15	12/94	6-7/94	Compact appliances	18	350	756	14
16	12/95	6-7/95	Compact appliances	17	364	791	15

Chart 22: Prices of microwave ovens in product tests



The data on price and quality provided by the product tests should also shed some light on the true trend in prices of microwave ovens. Since 1982 Stiftung Warentest has published a total of 16 tests (including two updates) on microwave ovens (Table 40). Five tests deal with combined appliances with a baking oven function. Such appliances are often used by small households in place of a baking oven. Three test deal with large-capacity appliances with a microwave function only. These, however, have recently lost considerable market share and are probably now mainly used for commercial purposes. The remaining tests deal with the modern compact appliances, some of which also have a grill. As in the other case studies, a large and a small sample were formed; the large sample contains all appliances while the small sample contains only compact appliances with a microwave function (i.e. models without a grill function).

As can be seen from the broken line in chart 22, the prices of microwave ovens in the tests likewise show a declining trend. In 1992 the price level in the official statistics was initially in line with the prices for larger one-function appliances but following the change in specification in the autumn of 1996 they tended to reflect the prices of smaller compact appliances.

Table 41: Price trends of microwave ovens

	(03/1982-07/1995)	(06/1987-07/1995)	(06/1992-07/1995)		
	Product tests total (n=228)	Single-function appliances (n=88)	Price index	Products tests, total (n=81)	Single-function appliances (n=37)
C(1)	7,12	6,33	4,61	8,17	6,10
t-statistic	123,8	123,2	3620,8	11,6	17,0
TIME	-0,006848	-0,006519	-0,001092	-0,014490	-0,003696
t-statistic	-11,1	-5,9	-18,5	-3,0	-0,8
R^2	0,27	0,31	0,90	0,09	0,02
Change in prices (in % p.a.)	- 7,9	- 7,5	- 1,3	- 16,0	- 4,3

For a comparison with the results of the hedonic price estimates which are also to be used for determining the quality-adjusted price decline of microwave ovens, the prices in the tests and the index figures in the Consumer Price Index were regressed to a simple time trend (Table 41).

This is probably less problematical here than in earlier case studies because microwave ovens have shown a fairly steady price decline rather than, say, alternating periods of faster and slower price rises. According to these calculations, the prices of such appliances declined by an average of about 8 % a year before quality adjustment; the price reduction in the case of the newer single-function compact appliances was somewhat less steep. The corresponding results for the shorter period from 1992 are to be interpreted with the utmost care because here the different composition of the sub-samples plays a major role.

The quality adjustment of price trends proves to be particularly difficult in the case of microwave ovens because many of the product improvements that are relevant to buying decisions are virtually impossible to measure. The main product characteristics that have been significantly changed are the operating safety, fittings and ease of use. The price reductions for well equipped compact appliances can best be seen from the headlines used by Stiftung Warentest. The headline in December 1992 read: "Good appliances from DM 500"; at the end of 1995 the headline ran: "Good appliances from DM 200".

Table 42: Price-determining characteristics of microwave ovens

VARIABLE	
UP TO DATE	Dummy=1 for model continuing to be sold with an unaltered specification.
POWER	Power in watts.
BUILT-IN	Dummy=1 for appliances that can be fitted.
GRILL	Dummy=1 for appliances with a grill.
BAK	Dummy=1 for appliances with a baking oven.
REV	Dummy=1 for appliances with a revolving platform.
VOL	Capacity in litres.
CONT	Dummy=1 for automatic continuation of the cooking process.
PROG	Dummy=1 for programmable appliances.

An ambivalent role is played by the interior capacity of microwave ovens. Although most consumers want a fairly large capacity, the cubic capacity of the interior varies in relation to the external dimensions when appliances of the same technical standard are compared. Moreover, there were hardly any smaller appliances at first for technical reasons. As microwave ovens are mostly used by households as secondary appliances, the minimum external dimensions for a long time stood in the way of greater market success. It was not until the modern compact appliances were introduced in the mid-eighties that a deep market penetration occurred. More so than in the case of the other products, the hedonic price estimates are therefore to be seen as no more than an initial approximation which can hardly extract more than a small part of the quality improvements from the prices. In contrast to the practice above, the IMPLICIT QUALITY CHANGE will be indicated in the following tables - along with the quality adjusted price changes - instead of the average bias, which cannot be taken into account owing the belated inclusion of microwave ovens in the price statistics. This is calculated approximately as the difference between the unadjusted and the adjusted rates of price changes.

For the entire sample, the quality-adjusted rates of price increase (Table 43) hardly differ from the result of the estimate without quality variables.[9] This is probably due mainly to the fact that the tests were initially often of large appliances and then, later, of smaller and simpler ones. The general improvement in the quality of microwave ovens is counteracted by this composition related quality deterioration with the result that the quality adjustment is zero on average. The true quality-adjusted price reduction in the market for microwave

[9] For reasons of space, there is no detailed discussion of the estimated results here.

Table 43: Quality-adjusted price changes of microwave ovens

(03/1982-07/1995)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	4	4	5
C(1)	0.47	5.84	1.82	173.66	5.90	1.76
t-statistic	0.0	43.7	1.9	1.6	55.6	2.2
UP TO DATE	151.44	0.16	0.16	79.91	0.09	0.11
t-statistic	5.1	4.1	4.0	2.4	2.2	2.6
POWER	0.59	0.001	0.64	0.46	0.001	0.67
t-statistic	2.6	3.1	3.8	2.3	4.1	4.6
BUILT-IN	192.96	0.20	0.20	118.77	0.12	0.12
t-statistic	4.8	4.6	4.6	3.3	3.4	3.2
GRILL	223.76	0.15	0.15	333.42	0.23	0.23
t-statistic	3.7	3.1	3.1	5.9	5.3	5.3
BAK	1061.62	0.73	0.76	965.75	0.62	0.67
t-statistic	11.2	13.2	12.1	10.8	12.5	11.3
REV	-147.10	-0.14	-0.14	-143.96	-0.13	-0.11
t-statistic	-4.1	-4.1	-3.9	-4.2	-3.8	-2.7
VOL	22.14	0.02	0.27	20.68	0.02	0.23
t-statistic	5.9	5.9	2.5	5.8	5.9	2.4
CONT	-	-	-	477.38	0.43	0.42
t-statistic	-	-	-	4.8	7.1	6.5
PROG	-	-	-	403.60	0.23	0.24
t-statistic	-	-	-	5.3	5.7	5.8
TIME	-0.006377	-0.006742	-0.007264	-0.006877	-0.007367	-0.008003
t-statistic	-10.6	-11.8	-11.0	-11.2	-12.7	-12.2
n	228	228	228	228	228	228
adj. R^2	0.83	0.83	0.82	0.89	0.89	0.88
SE	0.23	0.23	0.24	0.19	0.19	0.20
Quality-adjusted price change (in % p.a.)	- 7.4	- 7.8	- 8.3	- 7.9	- 8.5	- 9.2
Change in Quality (in % p.a.)	- 0.5	- 0.1	+ 0.4	+ 0.0	+ 0.6	+ 1.3

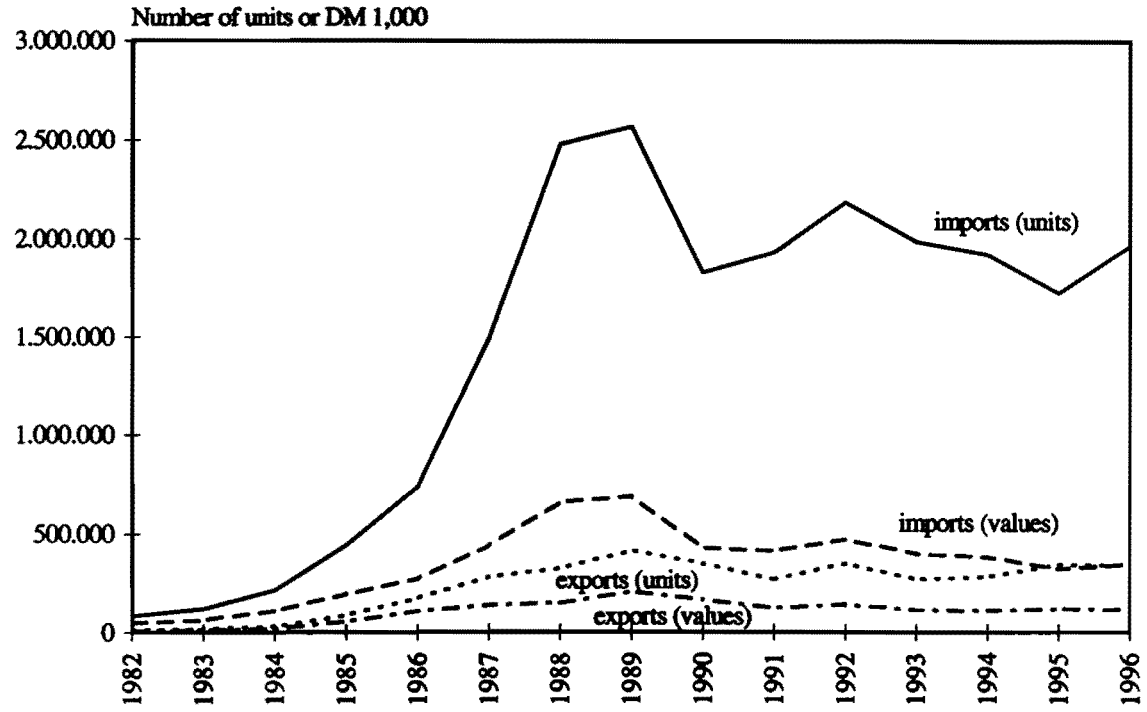
ovens will therefore probably have been appreciably more than 7 ½ % per annum if the change in the composition of the available range of appliances is taken into account. The more homogeneous sub-sample for compact single-function appliances shows much greater price reductions after quality adjustment (Table 44) and, accordingly, greater

Table 44: Quality adjusted price change of compact single-function microwave ovens

(06/1987-07/1995)	linear	semi-log	log-linear	linear	semi-log	log-linear
Number of brand dummies	-	-	-	not significant	not significant	not significant
C(1)	-71.51	5.38	0.80	-	-	-
t-statistic	-0.5	25.5	0.5	-	-	-
UP TO DATE	109.79	0.16	0.18	-	-	-
t-statistic	4.4	3.1	3.2	-	-	-
POWER	0.89	0.001	0.84	-	-	-
t-statistic	3.5	3.2	3.3	-	-	-
BUILT IN	141.09	0.21	0.21	-	-	-
t-statistic	3.2	3.4	3.5	-	-	-
CONT	340.74	0.34	0.33	-	-	-
t-statistic	3.5	4.6	4.5	-	-	-
PROG	544.61	0.39	0.41	-	-	-
t-statistic	2.4	4.9	5.1	-	-	-
TIME	-0.011263	-0.011270	-0.011215	-	-	-
t-statistic	-10.7	9.6	-10.1	-	-	-
n	88	88	88	-	-	-
adj. R^2	0.65	0.66	0.66	-	-	-
SE	0.23	0.23	0.23	-	-	-
Quality-adjusted price change (in % p.a.)	- 12.6	- 12.6	- 12.6	-	-	-
Change in Quality (in % p.a.)	+ 5.1	+ 5.1	+ 5.1	-	-	-

changes in quality, too. The 5 % rate of quality improvement established here may be interpreted as an approximation of the true rate of the improvement in the quality of microwave ovens. Supplementing the explanatory variables with a higher-order time polynomial proved to be statistically insignificant. The time dummy method did not yield very much different results either. Overall, there is little to suggest that the average quality-adjusted rate of price change cannot also be regarded as a good approximation for individual periods.

Chart 23: Imports and exports of microwave ovens



These estimates have not been made to highlight the quality improvements in microwave appliances but, instead, to assess the measurement bias arising from the exclusion of microwave ovens from the Consumer Price Index. For that purpose a breakdown of expenditure on microwave ovens and electric cookers on a annual basis and a time series for prices are required. Such figures are not provided by the official statistics. Consequently, recourse had to be taken to other data sources. In 1991 the relative weight of microwave ovens in the subindex "Electric Cookers and Electric Ovens" in the Consumer Price Index amounted to about one-third (0.045 % in the basket of goods as a whole). If the trend in imports and exports is taken as a guide (Chart 23), microwave ovens had their largest market share in 1988 and 1989. The relative weight of microwave ovens in this subindex is therefore put more or less arbitrarily at 0.5 for these years. As the analyses of the product tests went back only to 1982, the period when the ovens were introduced on to the market is not covered. For 1982 the market share of microwave ovens is estimated to have been 0.05. A steady decline of the relative importance to one-quarter is assumed until 1995 for the period following the greatest significance in terms of turnover.

Table 45: Model calculation of the measurement bias arising from the late inclusion of microwave ovens

	Price statistic		Calibration		Change against previous year in %			
	Index figure for electric cookers	Relative importance of electric cookers	Index figure for microwave ovens	Relative importance microwave oven	Index figure	Laspeyres index	Paasche index	Fisher index
1982	100.0	0.95	100	0.05				
1983	102.2	0.91	93	0.09	2.2	1.8	1.3	1.5
1984	103.1	0.85	86	0.15	0.9	0.5	-1.2	-0.4
1985	103.5	0.78	79	0.22	0.3	0.0	-3.1	-1.6
1986	104.1	0.70	73	0.30	0.6	0.3	-4.6	-2.2
1987	104.4	0.60	68	0.40	0.3	0.0	-7.1	-3.6
1988	104.5	0.50	63	0.50	0.1	-0.1	-8.7	-4.5
1989	105.6	0.50	58	0.50	1.0	0.7	-4.5	-1.9
1990	107.2	0.60	54	0.40	1.5	1.3	2.3	1.8
1991	110.9	0.67	50	0.33	3.5	3.2	2.9	3.0
1992	118.0	0.69	46	0.31	6.5	6.1	0.7	3.4
1993	119.0	0.71	42	0.29	0.8	0.7	-1.5	-0.4
1994	119.6	0.73	39	0.27	0.5	0.3	-1.4	-0.5
1995	119.8	0.75	36	0.25	0.1	0.0	-1.3	-0.6
	Price indices for „Electric cookers and electric ovens“				Deviation of the indices from the index figure in percentage point			
	Price statistic	Laspeyres index	Paasche index	Fisher index		Laspeyres index	Paasche index	Fisher index
1982	100.0	100.0	100	100.0		-	-	-
1983	102.2	101.8	101.3	101.5		-	0.5	0.9	0.7
1984	103.1	102.2	100.0	101.1		-	0.4	2.1	1.2
1985	103.5	102.2	96.9	99.5		-	0.3	3.6	1.9
1986	104.1	102.6	92.4	97.4		-	0.3	5.5	2.9
1987	104.4	102.6	85.8	93.8		-	0.3	8.0	4.1
1988	104.5	102.4	78.3	89.6		-	0.3	9.7	4.9
1989	105.6	103.2	74.8	87.9		-	0.3	5.7	3.0
1990	107.2	104.5	76.6	89.4		-	0.3	-0.8	-0.3
1991	110.9	107.8	78.7	92.1		-	0.3	0.6	0.4
1992	118.0	114.4	79.3	95.3		-	0.3	5.7	3.0
1993	119.0	115.2	78.1	94.9		-	0.2	2.4	1.3
1994	119.6	115.6	77.0	94.4		-	0.1	1.9	1.0
1995	119.8	115.6	76.0	93.8		-	0.1	1.4	0.8

The quality-adjusted index figure for microwave ovens was constructed by assuming a constant annual price reduction of 7.5 % in line with the hedonic estimate for the sample as a whole. In all probability, the measurement bias is underestimated as a result of this extremely conservative estimate. According to the results of the hedonic estimates, it is more probable that the true quality-adjusted price reduction was around 12 % a year.

The assumptions made for the model calculation for the individual years are again illustrated in Table 45. First of all, a Laspeyres index was calculated from the breakdown of expenditure in 1982 and was compared with the trend in the index figure for electric cookers in the Consumer Price Index. Initially there are fairly large deviations, but later only fairly small deviations, from the index figure in the consumer price index. The situation is quite different in the case of the other two index forms. The Paasche index in 1995 - the year in which microwave ovens were first included in the measurement of current inflation - is 36 percentage points below the subindex in the consumer price index, while the Fisher index - the geometric mean of the Laspeyres and the Paasche indexes - is 22 percentage points below the index level in the price statistics.[10] Although the annual rates of change from the previous period in the Fisher index are, strictly speaking, not very informative they are still useful for identifying the greatest deviations. Accordingly, in the year of the greatest sales, 1988, the peak level is reached with almost 5 percentage points; the average deviation was 1.9 percentage points. All in all, this is a very cautious estimate of the bias arising from the late inclusion of microwave ovens in the consumer price index.

[10] These are genuine indices with 1982 as the base year and not, for example, chain-linked indices. In the case of the latter, the typical problem of drifting occurs owing to the initial rise and subsequent fall in the sales importance of microwave ovens, which makes it impossible to interpret the chain indices meaningfully.

4. Extrapolation of the New Product Bias

> "As the preceding discussion should make clear, the scientific basis for making a judgement about the magnitude of the new-items effect is particularly thin."
> Shapiro/Wilcox (1996)

The principal considerations regarding the measurement problems that occur when new products enter the market and the analyses of the measurement bias in the case of microwave ovens have probably made it clear that paying adequate attention to new products when measuring inflation is more than a minor problem. Various aspects are at play here:

- If new products are not included in inflation measurement, the rise in prices will systematically be set too high because neither the consumer surplus arising from the new product itself nor the subsequent relative price reductions are taken into account.
- If new products are included at an early stage as part of a Laspeyres index, their effect on overall inflation is reflected in the index but their relative importance declines in the current measurement of inflation owing to their specific price trend; this results in a measurement bias because of the SUBSTITUTION PROBLEM.
- It often happens that new products undergo several modifications after their market launch, especially when new categories of purchasers are to be targeted. This means that, even if new products were represented in an index formula with a flexible weighting, the PROBLEM OF QUALITY ADJUSTMENT would arise in a particularly intensive form. Another point is that considerable problems with quality improvements arise in the price statistics when prices are falling in absolute terms.

The bias arising from the failure to record new products or from recording them too late should therefore to be seen in connection with the substitution problem and the problems of quality adjustment. The sooner new products are included in a basket of goods, the less pronounced will be the systemic measurement bias that arises when new products are not taken into account, but the greater will be the biases arising from the substitution problem and quality adjustment.

As it would be extremely time-consuming to verify the measurement bias resulting from the exclusion of new products in individual cases, most researchers are generally satisfied with notional approximations and simple plausibility calculations which are confined to the deviating price trend and disregard the initial increase in consumer surplus. A typical ques-

tion is which categories of expenditure are particularly affected by the emergence of new products.[11] These often include electrical household appliances, electronic games, telecommunications, computers, and audio and video equipment. Some authors, especially in the United States, include health services. Others point out that new products are continually appearing in all areas of life, say, in groceries. They argue that, generally speaking, it is therefore not the new product that is important but whether the new products follow the typical price trend and whether they quickly gain market shares.

In the plausibility calculations the estimated percentages of expenditure on new products are aggregated and then a price trend deviating from that of established goods is assumed. In doing so, the (average) relative price change for the new products that have not been taken into account is estimated to be all the smaller in terms of its absolute amount, the broader the estimated range of new products. Finally, a simple comparison is made over a 12-month period by giving the subindex for old products an index figure of 100 and that for new products one of, say, 95 (given a relative price decline of 5 % p.a.).[12] If 1 % of the budget is spend on new products, there is a bias of 0.05 percentage point (true index level: 100*0.99+95*0.01=99.95).[13]

It is very difficult to estimate the relevant share of expenditure and the corresponding price reduction. It is likely that microwave ovens had a share of approximately 0.1 % when their market importance was at its peak; the total share of new products would have been greater than 1 % only if there had been at least ten products of this kind. In the case of the microwave ovens mentioned, the relative price decline amounted to at least 10 % a year; if a generalisation could be made here, too, the bias would reach one-tenth percentage point annually. If the analysis were restricted to expenditure on high-tech products (excluding motor vehicles) with their typical price trends, it would be difficult to muster a 1 % expenditure share for new products. If, by contrast, food, various consumer goods in the field of health and body care and sport articles are added, a share of 2 % or more could not be ruled out. In that case, however, one would probably have to reduce the assumed relative price change to, say, - 5 % with the result that the outcome overall would remain at one-tenth.

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[11] See, for example, Lebow/Roberts/Stockton (1994), Congressional Budget Office (1994).

[12] By contrast, the Advisory Commission to Study the Consumer Price Index (1996) estimates the new product bias in connection with the quality change bias separately for different product categories. It uses the results of detailed studies for individual products where these are available.

[13] Fortin (1990), Crawford (1993), and Cunningham (1996) present similar calculations.

Table 46: Extrapolation of the new product bias (in percentage point p.a.)

Relative price change (in % p.a.)	Average relative importance of new products (in %)				
	0,1	0,2	0,5	1,0	2,0
-20	0,02	0,04	0,10	0,20	0,40
-15	0,02	0,03	0,08	0,15	0,30
-10	0,01	0,02	0,05	0,10	0,20
-5	0,00	0,01	0,03	0,05	0,10
-1	0,00	0,00	0,00	0,01	0,02

Furthermore, the quality bias would probably tend to be smaller in the event of fairly new weighting scheme. Overall, the bias resulting from new products seems to be important for individual product categories but, when considered in isolation, it is unlikely to attain a magnitude that is significant in macroeconomic terms.

VI. The Outlet Substitution Bias

1. Structural Changes in Retailing and their Implications for Inflation Measurement

Even products that are homogeneous in the strict sense are not sold at uniform prices at the retail level. For example, higher shop rents mean that goods sold in a town centre are usually more expensive than on the periphery of an agglomeration. Other, more important price differences are found between shops of different types. Modern discount stores regularly offer goods across the entire product range at lower prices than classical retailers. Much the same is true of specialist stores, such as hardware stores, compared with specialist shops of the older type. Furthermore, there are also indications that the price trend in the newer form of sale outlets is, on the whole, somewhat more favourable than in the case of the traditional retailers. Just as substitutions are made between individual goods given changes in their relative prices, consumers often take advantage of the newer and less expensive shopping facilities. Market shares then shift in favour of suppliers offering a better price-performance ratio. This raises the question how such changes in the retail structure are to be taken into account when measuring inflation.

Although the CONSUMER PRICE INDEX is drawn up in Germany on the basis of prices not only in traditional retailers but also in supermarkets and discount shops, UNWEIGHTED AVERAGES are calculated from the individual reports. However, this means that the price changes in shops with sluggish turnover have a greater impact on the calculated rate of inflation than increases in price in the larger stores, assuming that the prices in the latter are lower. This is a consequence of the implicit weighting of the price changes with the relative prices obtaining in the base period. The selling performance of the various types of outlet and how it changes are therefore not reflected directly in the price statistics.

Originally, the reporting units were to be selected so that the various types of outlet would be represented in the set of reporting units in line with their importance to turnover. The average of the prices would then have to be regarded as self-weighted. However, a systematic selection of the reporting units in terms of the market significance of the various types of outlet has not taken place for some time now, and the Federal Statistical Office does not

possess sufficient information at present to ascertain whether or not the choice of reporting units is still representative.

The price researchers normally remain with outlets for as long as possible once they have been chosen. This means that shifts in market shares do not result in a changing composition of the sample. Even if a reporting unit eventually disappears from the market because it is unprofitable, the price researchers often choose an outlet that is as similar as possible to the former one instead of changing to, say, a discount store which has taken over the market shares of the old retailer. Where it is not possible to change to a similar type of outlet, the price differential between the old and the new reporting units is completely eliminated as a difference in quality. Adequate account is therefore scarcely taken of the ousting of traditional retailers by new sales outlets with a superior price-performance ratio and of the potentially more favourable price trend found at the new suppliers. For that reason, in the German price statistics there is likely to be an OVERREPRESENTATION OF EXPENSIVE SHOPS WITH AN UNFAVOURABLE PRICE TREND and an underrepresentation of less expensive shops with a more advantageous price trend.

Unless there is a change in relative prices, however, neither a Laspeyres index nor a Paasche index show a slower rise in prices as a result of shifts in market shares even though the average price has fallen.[14] Superlative indices such as the Fisher index or the Törnqvist index do not show this either. Accordingly, a trend in average prices that deviates from the price index would not automatically indicate that there is a bias in the price statistics. Nevertheless, from the consumers' point of view the opening of a new outlet with a superior price-performance ratio in a specific locality has to be assessed similar to a product innovation.[15] The opening of an new outlet provides new shopping facilities, and consumers will change to the new supplier only if it is worth their while. For this reason, calculating price indices only with a change in weighting is misleading. Price series for the old and the new outlet should rather be chained. That is why changes in average prices often tend to give a closer approximation of the true price increase than the price indices.[16] It has to be remembered, however, that the new low-price suppliers often provide less service

[14] For details see Cunningham (1996).

[15] See Oulton (1995).

[16] See also Silver (1989) on the related problem of parallel markets.

and are frequently not so conveniently located;[17] however, the long-term changes in market shares show that the consumers prefer the new suppliers.[18]

Similar problems to the ones posed by changes in the trade structure arise in the case of DISCOUNTS, SPECIAL OFFERS and other PRICE REDUCTIONS. According to the instructions from the Federal Statistical Office, price researchers should include special offers of regular goods when recording prices;[19] however, prices quoted for end-of-season and clearance sales are to be excluded, as are special offers of substandard goods. Special difficulties arise for the price statistics in the case of price reductions which are only granted on demand or after individual negotiations. Special conditions affecting the purchase of motor vehicles are a frequently cited example of this. As price researchers are hardly in a position to haggle over prices, they have to rely on list prices. Depending on the given economic situation, however, traders will often be prepared to give a discount on the quoted price.

This could have an effect, above all, on the RECORDED PRICE RISES WITHIN THE BUSINESS CYCLE. When turnover is low, enterprises tend to be more willing to grant price reductions whereas they usually insist on the normal price in times of heavy demand. Accordingly, recorded price rises would be too low during the transition to a boom and too high in periods of recession. Whether or not a systemic bias arises outside the business cycle depends on whether or not the propensity to grant discounts changes overall.[20] Without access to (confidential) corporate data, however, no one is likely to obtain this information.

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[17] See Crawford (1993).

[18] See Advisory Commission to Study the Consumer Price Index (1996). Regarding the problems of taking account of changes in trading when measuring inflation, see Shapiro/Wilcox (1996), in particular, as well as Fixler (1993).

[19] See Statistisches Bundesamt (1990).

[20] See also Lequiller (1997).

2. Case Study No. 6: Changes in Unit Values and in Price Index Figures

In contrast to the biases arising from disregarding substitution and new goods and models, outlet substitution bias was, until recently, not widely regarded as a problem when measuring inflation. In a frequently cited study for the United States, Reinsdorf (1993) compared the trend in the average prices of food and fuels between 1980 and 1989 with the corresponding subindices in the consumer price index and established an annual deviation of 2 percentage point for food and of almost 1 percentage point for fuels. This means that, if these results are extrapolated to cover the entire basket of goods, an outlet substitution bias of more than 0.1 percentage point a year would not have been improbable for the United States.[21] It emerged later, however, that a large number of these deviations were not due to disregarding new trends in trade but rather to the unintentional side-effect of a problematical method of aggregating prices at the micro-level.[22]

This method is not used in Germany. A comparison such as that made by Reinsdorf would thus be an appropriate method of capturing outlet substitution bias for Germany.[23] However, this poses a number of problems which are essentially linked to the fact that unit values change from one period to the next not only as a result of rising or falling prices but also when there is a change in the PATTERN OF CONSUMPTION. If, for example, households in periods of stagnating real incomes and rising unemployment switch to products which are not only less expensive but also inferior in terms of quality, declining unit values would indicate a fall in prices which has not, in fact, taken place. The same would be true if households select less expensive shops offering a lower standard of service. Any comparison of unit values and the price index should therefore at least cover a complete business cycle. Even so, a figure established in this way would generally have to be seen as the upper limit of this bias; the quality differences between the various types of outlet would have to deducted from that.

In contrast to what Reinsdorf did in his analysis, no data from the price statistics are used in the following comparison; instead, UNIT VALUES FROM THE ABOVE-MENTIONED

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[21] See Lebow/Roberts/Stockton (1994).

[22] See Reinsdorf (1994) and (1998).

[23] See Diewert (1997), too, recommends this method.

CONTINUOUS FAMILY BUDGET SURVEYS are used.[24] Although it is actually the income and expenditure of selected households that are reported in the standard programme of these surveys, the surveyed households also record data on quantities bought of some foodstuffs, which means that unit values can be calculated. As in the case of the experimental price indices, the following analysis is essentially restricted to the period from 1986, making it possible to capture a more or less complete business cycle. However, some data are available from as early as 1980. The period from 1986 to 1996 is subdivided into two five-year periods, of which the first is one of buoyant economic conditions and the second a period of declining real incomes and rising unemployment.

Calculations for a total of 33 different foods were made. It emerges in the case of many of these products, however, that the unit values rose more sharply than the corresponding index figures in the consumer price statistics. This applies in particular to products with heterogeneous quality, which are neither very strictly defined in the price statistics nor in the Continuous Family Budget Surveys, such as beef or pork. Given that the price researchers reliably manage to record prices for products of constant quality, a rise of unit values in excess of the increase in the price index calculated on the basis of constant quality, indicates a change in the pattern of demand: as real incomes rise, consumers increasingly buy better-quality products which are therefore also more expensive. This becomes particularly clear if one looks at individual subperiods: the average prices of pork and beef (and of a number of other products) rose faster in the boom period of 1986 to 1991 than the price index; this trend then slackened or even went into reverse during the subsequent period of slow economic growth.

The following analysis is therefore confined to the products for which the relevant price index indicates a higher rate of price increase on average than do the unit values and, moreover, to cases where the product descriptions suggest greater homogeneity in terms of quality. The trends in unit values for the three types of household (H1, H2 and H3) as well as for the mean of the selected households (D) are shown for each product in table 47. This is followed by the trend in the corresponding subindices in the Consumer Price Index (LH1 for subindices and LHP for price representatives). Finally, the deviation of the change in the subindex from the unit values is calculated (BH1, BH2, BH3 and BD).

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[24] See page 24 regarding the Continuous Family Budget Surveys.

Table 47: Price trends of selected goods in the Consumer Price Index and in the Continuous Family Budget Surveys

(Change in % p.a. or differences in percentage point p.a.)		1996 comp. with 1980	1996 comp. with 1986	1986 comp. with 1980	1991 comp. with 1986	1996 comp. with 1991
1. Mince	H1	-0.4	-0.2	-0.8	0.5	-0.9
	H2	0.0	0.3	-0.6	1.7	-1.0
	H3	0.4	0.5	0.3	1.3	-0.2
	D	0.1	0.3	-0.3	1.3	-0.7
Mince,	LHP	1.1	0.9	1.5	0.9	0.9
half beef, half pork,	BH1	1.6	1.2	2.3	0.4	1.9
fat content	BH2	1.2	0.6	2.1	-0.8	2.0
less than 30 %,	BH3	0.7	0.4	1.2	-0.4	1.1
	BD	1.1	0.6	1.7	-0.4	1.6
2. Milk	H1	-	-0.1	-	0.9	-1.1
	H2	-	0.6	-	2.5	-1.1
	H3	-	1.0	-	3.5	-1.5
	D	-	0.6	-	2.6	-1.3
Milk	LHI	-	1.3	-	1.7	0.9
	BH1	-	1.4	-	0.8	2.0
	BH2	-	0.6	-	-0.7	2.0
	BH3	-	0.3	-	-1.7	2.4
	BD	-	0.6	-	-0.9	2.2
3. Eggs, fresh	H1	0.4	1.1	-0.7	1.7	0.5
	H2	0.6	1.4	-0.6	2.1	0.7
	H3	1.1	2.0	-0.4	2.3	1.8
	D	0.7	1.5	-0.6	2.0	1.1
German eggs,	LHP	1.3	1.7	0.6	2.0	1.4
quality category a,	BH1	0.9	0.6	1.3	0.3	0.9
weight category 2,	BH2	0.6	0.3	1.2	-0.1	0.7
in cartons of ten	BH3	0.2	-0.3	1.0	-0.2	-0.4
	BD	0.5	0.2	1.2	0.0	0.3
4. Butter (including	H1	-0.9	-1.1	-0.6	-2.0	-0.2
low fat butter und	H2	-1.0	-1.2	-0.6	-1.7	-0.8
clarified butter)	H3	-0.8	-1.0	-0.5	-1.6	-0.3
	D	-0.9	-1.1	-0.5	-1.8	-0.4
German non-	LHP	-0.2	-0.6	0.5	-1.4	0.3
blended butter,	BH1	0.7	0.5	1.1	0.6	0.5
in 250g packs	BH2	0.8	0.6	1.0	0.3	1.0
	BH3	0.6	0.4	1.0	0.2	0.5
	BD	0.7	0.5	1.0	0.3	0.7
5. Margarine	H1	-0.6	-0.2	-1.2	-1.6	1.2
	H2	-0.6	0.3	-1.9	-0.4	1.0
	H3	-0.4	0.1	-1.2	-0.5	0.8
	D	-0.5	0.2	-1.5	-0.6	1.0
Margarine	LHI	0.0	0.5	0.0	-1.0	1.9
	BH1	0.6	0.7	1.2	0.6	0.7
	BH2	0.6	0.2	2.0	-0.6	0.9
	BH3	0.4	0.3	1.2	-0.5	1.1
	BD	0.5	0.3	1.5	-0.4	0.9
6. Bananas	H1	2.2	1.3	3.8	-1.2	3.8
	H2	2.2	1.3	3.6	-0.4	3.2
	H3	2.5	1.7	3.7	-0.5	4.0
	D	2.3	1.5	3.7	-0.6	3.7
Bananas,	LHP	3.2	2.2	5.1	0.2	4.7
not over-ripe	BH1	1.0	0.9	1.2	1.4	0.8
	BH2	1.0	0.8	1.4	0.6	1.5
	BH3	0.8	0.4	1.4	0.7	0.6
	BD	0.9	0.7	1.3	0.8	1.0

(Change in % p.a. or differences in percentage point.p.a.)		1996 comp. with 1980	1996 comp. with 1986	1986 comp. with 1980	1991 comp. with 1986	1996 comp. with 1991
7. Sugar	H1	0.8	-0.1	2.3	-0.5	0.3
(beet and	H2	1.1	0.1	2.7	0.1	0.1
cane sugar)	H3	1.2	0.3	2.7	0.0	0.6
	D	1.0	0.1	2.6	-0.1	0.3
Sugar, fine,	LHP	1.0	0.3	2.3	0.0	0.5
in 1 kg EC bags,	BH1	0.3	0.4	0.0	0.6	0.2
category i	BH2	0.0	0.2	-0.3	-0.1	0.5
	BH3	-0.1	0.0	-0.3	0.0	0.0
	BD	0.0	0.2	-0.2	0.1	0.2
8. Wheat flour	H1	-1.4	-1.8	-0.7	-1.0	-2.7
	H2	-1.0	-1.3	-0.5	0.9	-3.4
	H3	-0.4	-1.2	1.0	0.1	-2.4
	D	-0.9	-1.4	0.0	0.1	-2.8
Wheat flour,	LHP	0.2	-0.2	0.9	0.3	-0.7
type 405,	BH1	1.6	1.7	1.6	1.3	2.1
in 1 kg bags	BH2	1.2	1.1	1.4	-0.6	2.9
	BH3	0.6	1.0	-0.1	0.2	1.8
	BD	1.1	1.2	0.9	0.2	2.2
9. Rice	H1	1.1	0.2	2.6	-1.0	1.4
	H2	1.0	-0.5	3.5	-0.9	-0.2
	H3	1.5	-0.1	4.2	-0.1	-0.1
	D	1.2	-0.2	3.6	-0.6	0.2
Rice	LHP	1.9	1.4	2.8	1.5	1.4
	BH1	0.8	1.2	0.2	2.5	-0.1
	BH2	1.0	2.0	-0.7	2.4	1.6
	BH3	0.5	1.6	-1.3	1.7	1.5
	BD	0.7	1.7	-0.8	2.2	1.2
10. Cooking salt	H1	-	1.0	-	0.9	1.2
	H2	-	1.4	-	2.8	-0.1
	H3	-	1.0	-	0.5	1.5
	D	-	1.0	-	1.3	0.8
Cooking salt	LHP	-	2.0	-	1.6	2.4
	BH1	-	1.0	-	0.7	1.2
	BH2	-	0.7	-	-1.2	2.5
	BH3	-	1.0	-	1.1	0.9
	BD	-	1.0	-	0.3	1.6
11. Coffee	H1	-2.1	-4.3	1.6	-8.9	0.6
	H2	-	-4.2	-	-8.6	0.4
	H3	-1.6	-3.9	2.4	-8.6	1.1
	D	-	-4.1	-	-8.7	0.7
Coffee, ground,	LHP	-1.0	-3.1	2.5	-8.1	2.3
in 500 g packs,	BH1	1.1	1.3	0.9	0.9	1.7
medium quality	BH2	-	1.2	-	0.5	1.9
	BH3	0.5	0.8	0.1	0.5	1.2
	BD	-	1.1	-	0.6	1.6

H1: average price household type 1 (two-person households pensioners or recipients of social assistance).
H2: average price household type 2 (four-person households of salary or wage earners with a middle income of a married sole earner).
H3: average price household type 3 (four-person households of civil servants or salary earners with higher income).
D: average price for the average of the three types of household (sum of expenditure/sum of volumes).
LHP: consumer prices.
LH1: subindices of the Consumer Price Index.
BH1, BH2, BH3 and BD: deviation of consumer prices or price indices from average prices.

In the case of butter, for example (No. 4 in table 47), the annual rise in unit values between 1986 and 1996 was ½ percentage point slower than the increase of the the price index calculated on the basis of constant product quality. As there is no evidence that consumers continually buy butter of inferior quality, this deviation is likely to be due to changes in shopping habits. In the case of wheat flour (No. 8) the average deviation amounted to 1.2 percentage point and in the case of cooking salt (No. 10) to 1.0 percentage point a year. In each case there were much greater differences in the first half of the nineties than at the end of the eighties; this does not necessarily suggest an accelerated structural change in retailing but, instead, is a sign of cyclically induced changes in buying behaviour.[25] Much the same is true of the other products listed in Table 47. The extent of the deviations over the ten-year period from 1986 is between 0.2 and 1.7 percentage points a year.

What is open to question is the extent to which the differences in price rises are due to quality differences between the various types of outlet. Some commentators argue that the service in the new generation of sales outlets is, in all cases, worse than in the classical retail shops and that the price differential is therefore essentially a reflection of the quality differential. What is frequently overlooked, however, is the fact that modern discount stores and specialist outlets often provide a much greater selection of products.[26] Nevertheless, this advantage is likewise disregarded in measuring the level of prices so that at least one effect counteracting the lower standard of service emerges.

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[25] See also Cunningham (1996).

[26] This point is emphasised, in particular, by the Advisory Commission to Study the Consumer Price Index (1996).

3. Extrapolation of the Outlet Substitution Bias

There is much to suggest that the price trends of some products are not accurately captured in the Consumer Price Index because of the changing retail structure, and that the resultant bias in the rate of inflation is greater than zero. Even so, extrapolating the outlet substitution bias is extremely difficult because more detailed information on differing price trends in the various types of outlets and on the corresponding shifts in market shares is not available from official sources. Owing to problems regarding quality, estimating the bias indirectly via average prices is not possible either for the majority of products.

However, in this respect the situation in Germany is not essentially different from that in other countries. Extrapolations of the outlet substitution bias are therefore mostly based on plausibility considerations regarding the products concerned, price differences and differences in inflation trends as well as shifts in market shares. The extent of the bias should be considered from all sides, taking very low values, on the one hand, and very high values, on the other, for these parameters. In his calculation for Canada, Crawford (1993) assumes a quality-adjusted price differential between old and new suppliers, while Cunningham (1996) assumes varying trends of price increase in his study for the United Kingdom. Both emphasise that the assumed price differences involved must be temporary phenomena: when the structural change in retailing is completed, the outlet substitution bias must also be zero.

It is assumed in the following extrapolation for western Germany that both foodstuffs and manufactured goods are affected by the structural change in retailing but that similar phenomena hardly occur in the case of dwellings and services.[27] This bias would then affect about 50 % of the expenditure of private households.

In the past few years the CHANGE IN THE RETAIL STRUCTURE has been marked by a switch on the part of consumers from traditional specialist shops and department stores to modern discount stores and specialist markets. These shifts in market shares began in grocery retailing and later extended to do-it-yourself goods and drugstore articles. This trend

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[27] This could change increasingly in the case of services. Examples of new form of selling outlets with lower prices and restricted levels of service are direct banking, last-minute agencies for holiday travel and low-price airlines.

Table 48: Changes in the retail structure in western Germany

Type of outlet	Market shares (in %) 1980	1986	1992	1995 (estimate)
Traditional specialist stores	55.4	46.7	38.2	35.4
Department stores (Kaufhof, Karstadt, Hertie, Horten, Woolworth)	7.2	5.6	5.4	5.8
Mail order business	5.5	5.3	5.4	5.5
„Old" types of outlets, total	68.1	57.6	49.0	46.7
Small- and medium-size self-service shops (supermarkets and discount stores)	18.0	19.6	21.4	21.8
Consumer markets / self-service department stores (with food halls)	11.9	15.3	17.2	17.5
Specialist markets	2.0	7.5	12.4	14.0
„New" types of outlets together	31.9	42.4	51.0	53.3
Shift in market shares	-	1980 to 1986	1986 to 1992	1992 to 1995
Total (in percentage point)	-	10.5	8.6	2.3
Per annum (in percentage point)	-	1.8	1.4	0.8

Source: Monopolkommission (1994); own calculations.

has recently continued in entertainment electronics and computers.[28] According to the calculations in table 48 the shifts in market shares were especially pronounced in the first half of the eighties, after which the pace of structural change slackened. In the first half of the nineties the new generation of selling outlets were able to gain no more than just under 1 percentage point of market shares a year. This calculation could amount to an underestimation of the structural change since the older supermarkets, which are confronted with enormous competitive pressure from the discount stores, are combined with the latter in one category. On the other hand, data from other sources also indicate a deceleration of the structural change. Consequently, estimates have been based alternatively on shifts in market shares of 0.5, 1, 1.5 and 2 percentage points a year.

According to studies on the overall price level conducted by market research enterprises, the unadjusted price differential between discount stores and supermarkets in Germany, among which structural change has been taking place very rapidly, amounts to up to 15

[28] See Monopolkommission (1994).

Table 49: Extent of the outlet substitution bias (in percentage points)
(extrapolated from 50 % of the expenditure total to cover the entire basket of goods)

Annual shifts in market shares (in percentage point)	Price differential between old and new outlets (in percentage point)		
	5.00	10.00	15.00
0.5	0.01	0.03	0.04
1.0	0.03	0.05	0.08
1.5	0.04	0.08	0.11
2.0	0.05	0.10	0.15

percentage points. According to these studies, the average rate could be 5 percentage points. Although there are likely to be differences in service, the shifts in market shares show that consumers prefer the price-performance ratio of the discount stores. Price differentials of 5, 10 and 15 percentage points are therefore assumed when estimating the bias. The results of the calculations are given in table 49 These show that fairly extreme assumptions have to be made to find a bias of one-tenth or more.

VII. Conclusion

At the end of this long traversal of German consumer price statistics, there finally arises the question of the overall result, or of the SIZE OF THE BIAS IN INFLATION MEASUREMENT IN GERMANY, if a cost-of-living index is chosen as a yardstick. Studies in the US have found that inflation is overstated by ½ to 1 ½ percentage points. These projections are based on a whole range of detailed studies carried out there during the past few years. Despite the large number of individual findings, the assessment of the overall bias still turns out to be rather mixed, and even individual authors often mention large margins of uncertainty.

Given the fact that the situation regarding detailed case studies is much worse for Germany, it seems presumptuous to attempt a projection of the overall bias. However, at the end of such a study, the question of the overall bias inevitably arises. Therefore, the individual results for (western) Germany are to be extrapolated in this section. This projection is subject to the qualification that detailed studies on problems of price measurement are in short supply in Germany. Therefore, we are dealing with a more or less educated guess which only lays a limited claim to a scientific basis.

The detailed results of the study are as follows:

- The PRODUCT SUBSTITUTION BIAS concerns the distortion caused by using a Laspeyres formula to aggregate price changes at the macro-level. According to the Laspeyres method, inflation is measured using a basket of goods fixed over a relatively long period. This basket may become outdated; in that case, however, the rate of price increases may be overstated. What Diewert calls superlative indices may permit a closer approximation of the true rate of inflation, especially if these forms are chain-linked annually. For this study, various experimental price indices have been calculated for the period from 1986 to 1996. The relevant information about expenditure patterns comes from the Continuous Family Budget Surveys of the Federal Statistical Office. The substitution base was then determined by the deviation of an experimental Laspeyres index with a fixed basis from the superlative (Fisher, Törnqvist) price indices. Accordingly, the differences between the various indices tend to be small. For foodstuffs, where a sufficient amount of detailed information exists in the Continuous Family Budget Surveys, the bias amounted to around 1/20 of a percentage point per year; for private consumption overall, however, a substitution bias of 1/10 cannot be ruled out.

- The QUALITY CHANGE BIAS: Problems concerning the quality adjustment of price differences are probably the major source of bias in inflation measurement. Products are often redesigned. That leads to the problem of calculating quality-adjusted prices for new models. The recorded rate of inflation therefore depends mainly on how accurately the statistical offices adjust price changes for variations in quality. For that reason, this problem is of paramount importance for the informative value of price indices.

  In contrast to US studies, where the results of detailed studies were extrapolated, another course had to be taken here. The starting point was a theoretical analysis of the Federal Statistical Office's instructions for the quality adjustment of prices. It emerged that the quality change bias was to be small for price changes in the vicinity of the product-specific quality change and indeterminate in terms of its sign, but that the bias becomes large and positive with very low or very high product-specific price increases that are further removed from the rate of growth in quality.

  It was possible to confirm this pattern in three case studies for washing machines, refrigerators and freezers. Initially, unadjusted average prices from the consumer price statistics were compared with the quality-adjusted sub-indices from the Consumer Price Index. In line with the theoretical argument, it was revealed that the statistical offices make adjustments for quality changes especially in periods of moderately rising prices, but that these adjustments are often not made whenever prices are stagnating or falling. This pattern was confirmed by hedonic price studies in which price changes are explained econometrically by product characteristics and a time variable. Finally, these results were extrapolated using some stylised facts.

  On the basis of the assumed simple model of price formation, the following picture emerges: If inflation is moderate and overall price level stability has been nearly achieved, the bias caused by the generalising rules for quality adjustment will be just under ½ percentage point per annum, if an overall advance in quality of 1 % is assumed. Below this area, i.e. given falling prices, the bias increases rapidly. As a maximum it could be in the region of one percentage point per annum. If inflation is higher, the bias might also be over ½ percentage point p.a.. This assessment of the quality change bias holds for the case where the price researchers strictly adhere to the instructions of the Federal Statistical Office; otherwise, the error may be larger (or also smaller).

- The NEW PRODUCT BIAS includes, firstly, the bias caused by including new goods too late in inflation measurement. They usually show distinct relative price decreases in the first phase of the product life-cycle. Without immediately incorporating new goods, the overall rate of inflation is therefore overstated. In addition, the welfare gain when new

goods are introduced is not taken into account in measuring inflation, although this is usually the case for new product variants (i.e. for quality changes). For that reason, too, the rate of price increase is overstated. The implications of this method have been shown in detail using the sub-index for "Electric cookers and electric ovens". Even though the bias can be large for individual sub-indices, the problem of generalisation arises here, too. In line with studies conducted abroad, the result is - excluding introductory gains - probably a bias of not more than 0.1 percentage point. Including the welfare gains which accompany the appearance of new goods, the new product bias could also be higher, however.

- OUTLET SUBSTITUTION BIAS is the name given to the bias which arises in inflation measurement by overlooking the radical changes in retailing. Whereas price statistics, following the Laspeyres principle, adhere to the same reporting units once they have been chosen, consumers switch to new outlets with a more favourable price-performance ratio. Indications of a bias are provided by a comparison of the changes in unit values from the Continuous Family Budget Surveys and the relevant sub-indices from the Consumer Price Index. For narrowly defined products, where quality changes should not play a major role, price increases are much lower according to the Continuous Family Budget Surveys than according to the price statistics.

  However, it remains unclear whether these differing price trends might not be explained by latent quality differences, such as reduced service in less expensive outlets. Detailed consumer surveys such as those carried out by market research enterprises would be needed to determine the outlet substitution bias precisely. Since an analysis of such data would have gone beyond the scope of this study, which is more of an exploratory nature, the estimation of this bias is made primarily on the basis of plausibility considerations; overall, the outlet substitution bias is unlikely to exceed 0.1 percentage point annually.

Therefore, one cannot rule out the possibility that the bias in the Consumer Price Index in "normal" circumstances will total some ¾ percentage point annually, placing it at the lower end of the margin for the United States. In times of generally declining prices, however, the bias may well be larger, because in this case the instructions of the Federal Statistical Office are less adequate on average. However, much caution is warranted when making these conclusions regarding distortions of the rate of inflation in historical situations. Negative rates of inflation have occurred only temporarily in Germany - in 1986 - under the impact of dramatically falling oil price quotations. Even in that period, the prices of manufactured products (which account for a large percentage of the quality changes that create problems

in inflation measurement) continued to rise on average. Accordingly, it would not be appropriate to assume a maximum bias for that period, such as was estimated here.

The bias might rise somewhat with accelerating inflation, too. This is not of too great significance for economic policy, however. If the value of money were depreciating at a rate of, say, over 10 % a year, a measurement bias of just over 1 percentage point would be of only secondary importance; what is then of primary importance is returning to an appropriate price trend.

The problem of a variable bias has also been discussed in studies for other countries. Firstly, there are indications that, given rising inflation, the substitution bias may increase owing to a greater spread of the rates of price increases for individual goods. Secondly, some have considered that progress in quality may have been more rapid in the past and that the bias may therefore be smaller today than in the past. This may also be the case in Germany; this study was unable to find any indications of this, however. Rather, the variability of the bias here depends on the rate of inflation itself and on the instructions of the Federal Statistical Office on quality adjustments and not, say, on retarded or accelerated technological development.

Even if, given a moderate rate of inflation, the measurement bias in the rate of inflation tends to be lower overall than according to the most recent estimates made for the United States, there is still no cause to give the all clear signal. Major biases for individual products are diluted by no more than possibly very small deviations for other products so that the margin of error is satisfactory overall for the result; this is not so for individual subindices, however. Particularly in the field of manufactured products, major discrepancies between the recorded rate of inflation and a true rate of inflation will have to be expected.

This is likely to play a major role especially in the context of the NATIONAL ACCOUNTS. Usually, output and expenditure components of Gross Domestic Product are deflated at a low level of aggregation with the relevant Laspeyres price indices from the price statistics. If the problems of the quality adjustment of prices are concentrated on a very few goods and services (e.g. computers, software, pharmaceuticals, medical services), these biases would probably be sufficiently "diluted" by components which pose no problems for the measurement of overall economic growth when they are aggregated, but the real rates of growth of individual aggregates, some of which are quite important, could still not be interpreted meaningfully.

The bias in inflation measurement was calculated in this study based on a COST OF LIVING INDEX as a point of reference. The statistical authorities in most countries, however, do not pursue such an ambitious strategy; rather, only an UNCONTAMINATED RATE OF PRICE RISES is to be recorded. Thus, the question would have to examined of whether the bias calculations made here are still relevant if this more modest yardstick is applied.

The METHODOLOGICAL PRINICPLES OF THE GERMAN CONSUMER PRICE INDEX rest primarily on three foundations:

- A LASPEYRES INDEX with a fixed basket of goods is calculated.
- When selecting the goods which are to be included in the basket and allocating the shares of expenditure to those goods, the principle of REPRESENTATIVE WEIGHTING shall apply: the price representatives that are selected should also represent the goods not taken into account through their specific price movement.
- Only UNCONTAMINATED PRICE CHANGES should be included in the inflation calculation. Quality changes should therefore be eliminated.

The Laspeyres principle presupposes that neglecting the short-term substitution effect should be accepted. Thus, the short-term product substitution bias (e.g. over a year), would have to be accepted, as would the short-term outlet substitution bias. Otherwise, the biases mentioned would also apply to an index as designed by the Federal Statistical Office. It is often argued that, when concentrating solely on the "uncontaminated" rate of price increase, there is neither a product substitution bias nor an outlet substitution bias and no new product bias either. However, this overlooks the fact that disregarding new goods and their particular price trend violates the principle of representative weighting. Much the same applies when there is a shift in market shares in trade and between various goods if they took place, for instance, longer than one year ago. In addition, when introducing new products, utility gains should be included, as is the case for new model variants of known products - i. e. quality changes.

Thus, if there are clear indications that the rate of inflation is overstated by the Consumer Price Index in Germany, too, this raises the question of its IMPLICATIONS FOR PRICE STATISTICS. First of all, it should be stated that all statistical information is compiled with less than complete accuracy, and that bias-free statistics would only be possible with an unjustifiably high input of resources and at the expense of the up-to-dateness of the reports. The question of improving the consumer price statistics, therefore, also has a COST-BENEFIT BACKGROUND. Apart from, perhaps, possible cost-saving reforms, increased

accuracy in inflation measurement would entail higher expenditure (for additional data and staff), which would probably rise disproportionately with each gain made in accuracy. By contrast, the increase in utility would probably decline. Therefore, from an overall point of view, there is likely to be an optimum level of accuracy in inflation measurement.

As resources are on the whole scarce, it would undoubtedly be inefficient to strive for maximum accuracy in the measurement of inflation. In particular, it might be all too easy to overlook the fact that increased accuracy in measuring inflation in many cases also presupposes improved data from other statistical programmes. Without detailed and up-to-date information on households' buying and consumption habits, for instance, the annual rebasing of price indices would entail additional work, but would only create the appearance of improved accuracy, instead of a more accurate picture of the true rate of inflation.[1] Nevertheless, improvements should be striven for, especially in the quality adjustment of prices. However, further preliminary research would first be necessary in order to be better able to identify the areas where action needs to be taken. In some cases, such research is already being coordinated by Eurostat as part of the harmonisation of European price statistics. In particular, the counts of the methods of quality adjustment suggested by Eurostat and the calculation of reference indices without quality adjustments might be very useful.

[1] See also Glaab (1995).

References

Abraham, Katharine G. (1997) *Testimony Before the House Budget Committee March 12.* Mimeo, Bureau of Labor Statistics.

Advisory Commission to Study the Consumer Price Index (Michael J. Boskin, Ellen R. Dulberger, Robert J. Gordon, Zvi Griliches, and Dale Jorgenson) (1996) *Toward a More Accurate Measure of the Cost of Living.* Final Report to the Senate Finance Committee. Washington D.C.: Senate Finance Committee.

Aizcorbe, Ana M., and Patrick C. Jackman (1993) The Commodity Substitution Effect in CPI Data, 1982-1991. *Monthly Labor Review* 116, pp. 25-33.

Angermann, Oswald, and Carsten Stahmer (1976) Preisindices und Geldwertmessung im Rahmen der Volkswirtschaftlichen Gesamtrechnungen. In: Gerhard Fürst (ed.) *Messung der Kaufkraft des Geldes.* Sonderheft 10 zum *Allgemeinen Statistischen Archiv*, pp. 101-127. Göttingen: Vandenhoek & Ruprecht.

Arguea, Nestor M., and Cheng Hsiao (1993) Econometric Issues of Estimating Hedonic Price Functions. With an Application to the U.S. Market for Automobiles. *Journal of Econometrics* 56, pp. 243-267.

Armknecht, Paul A. (1984) Quality Adjustment in the CPI and Methods to Improve It. *Proceedings of the Business and Economic Statistics Section*, pp. 57-63. Washington: American Statistical Association.

Armknecht, Paul A.(1996) *Improving the Efficiency of the U.S. CPI.* IMF Working Paper WP/96/103.

Armknecht, Paul A., and Daniel H. Ginsburg (1992) Improvements in Measuring Price Changes in Consumer Services: Past, Present, and Future. In: Zvi Griliches (ed.) *Output Measurement in the Service Sectors.* Studies in Income and Wealth 56, pp. 109-156. Chicago: University of Chicago Press

Balk, Bert M. (1990) On Calculating Cost-of-Living Index Numbers for Arbitrary Income Levels. *Econometrica 58*, pp. 75-92.

Baxter, Michael (1997) Implications of the US Boskin Report for the US Retail Price Index. *Economic Trends* No. 527, pp. 56-62.

Berndt, Ernst R. (1983) Quality Adjustment, Hedonics, and Modern Empirical Demand Analysis. In: W. Erwin Diewert, and C. Montmarquette (eds.) *Price Level Measurement. Proceedings from a Conference Sponsored by Statistics Canada.* Ottawa: Statistics Canada, pp. 817-863.

Berndt, Ernst R. (1991) *The Practice of Econometrics: Classic and Contemporary.* Reading, MA: Addison-Wesley.

Berndt, Ernst R., Ian Cockburn, and Zvi Griliches (1996) Pharmaceutical Innovations and Market Dynamics: Tracking Effects on Price Indexes for Antidepressant Drugs. *Brookings Papers on Economic Activity, Microeconomics*, pp. 133-188.

Blow, Laura, and Ian Crawford (1997) *A GARP Method for Overcoming New Goods Bias in Price Indices with an Application to the UK National Lottery.* Institute for Fiscal Studies.

Blow, Laura, and Ian Crawford (1998) *A Quality-constant Price Index for New Cars in the UK, 1986 to 1995.* Institute for Fiscal Studies.

Boskin, Michael J. (1997) Lies, Damned Lies and (Faulty) Statistics. *International Economy*, Jan/Feb, pp. 14-18.

Boskin, Michael J., Ellen R. Dullberger, Robert J. Gordon, Zvi Griliches, and Dale W. Jorgenson (1998) Consumer Prices, the Consumer Price Index, and the Cost of Living. *Journal of Economic Perspective* 12, No. 1, pp. 3-26.

Braithwait, Steven D. (1980) The Substitution Bias of the Laspeyres Price Index: An Analysis Using Estimated Cost-of-Living Indexes. *American Economic Review* 70, pp. 64-77.

Bureau of Labor Statistics (1997) *Measurement Issues in the Consumer Price Index.* Mimeo.

Burstein, Meyer L. (1961) Measurement of Quality Changes in Consumer Durables. *Manchester School of of Economic and Social Studies* 29, pp. 267-279.

Carruthers, A. G., D. J. Sellwood, and P. W. Ward (1980) Recent Developments in the Retail Prices Index. *The Statistician* 29, pp. 1-32.

Cartwright, David W. (1986) Improved Deflation of Purchases of Computers. *Survey of Current Business* 66 (March), pp. 7-9.

Cecchetti, Stephen G. (1986) The Frequency of Price Adjustment. A Study of the Newsstand Prices of Magazines. *Journal of Econometrics* 31, pp. 255-274.

Chow, Gregory C. (1967) Technological Change and the Demand for Computers. *American Economic Review* 57, pp. 1117-1130.

Cole, Rosanne, Y. C. Chen, Joan A. Barquin-Stolleman, Ellen Dullberger, Nurhan Helvacian, and James H. Hodge. (1986) Quality-Adjusted Price Indexes for Computer Processors and Selected Peripheral Equipment. *Survey of Current Business* 66, pp. 41-50.

Combris, Pierre, Sébastien Lecocq, and Michael Visser (1997) Estimation of a Hedonic Price Equation for Bordeaux Wine: Does Quality Matter? *Economic Journal* 107, pp. 390-402.

Congressional Budget Office (1994) *Is the Growth of the CPI a Biased Measure of Changes in the Cost of Living?* CBO Papers. Washington D.C.: Congressional Budget Office.

Court, A.T. (1939) Hedonic Price Indexes. With Automotive Examples. In: General Motors Corporation (ed): *The Dynamics of Automobile Demand.* New York, NY: General Motors Corporation, pp. 99-117.

Cowling, Keith, and John Cubbin (1972) Hedonic Price Indexes for United Kingdom Cars. *Economic Journal* 82, pp. 963-978.

Crawford, Allan (1993) Measurement Biases in the Canadian CPI: A Technical Note. *Bank of Canada Review*, Summer, pp. 21-36.

Crawford, Allan (1998) Measurement Biases in the Canadian CPI: An Update. *Bank of Canada Review*, Spring, pp. 38-56.

Cropper, Maureen L., Leland B. Deck, and Kenneth E. McConnell (1988) On the Choice of Functional Form for Hedonic Price Functions. *Review of Economics and Statistics* 70, pp. 668-675.

Cunningham, Alastair W. F. (1996) *Measurement Bias in Price Indices: An Application to the UK's RPI.* Bank of England Working Paper Series 47.

Cutler, David M., Mark McClellan, and Joseph P. Newhouse, and Dahlia Remler (1996) *Are Medical Prices Declining?* NBER Working Paper 5750.

Dalén, Jörgen (1998) Studies on the Comparability of Consumer Price Indices. *International Statistical Review* (1998), pp. 83-113.

Danner, Peter (1975) Das Berechnungsverfahren beim Preisindex für die Lebenshaltung. *Zeitschrift des Bayerischen Statistischen Landesamtes* 107, pp. 21-54.

de Leeuw, Frank (1993) A Price Index for New Multifamily Housing. *Survey of Current Business* 73 (February), pp. 33-42.

Deneffe, Peter (1950) Zur Preisindexziffer für die Lebenshaltung. *Wirtschaft und Statistik* 2, pp. 207-211.

Deneffe, Peter (1958) Das Problem der Berücksichtigung qualitativer Veränderungen im Rahmen der Preisstatistik. *Allgemeines Statistisches Archiv* 42, pp. 346-353.

Deneffe, Peter, and Ingetrud Hiller (1958) Zum Preisindex für die Lebenshaltung. Entwicklung der Ausgaben, der Preise und des Lebensstandards. *Wirtschaft und Statistik* 10, pp. 539-545.

Deneffe, Peter, and Josef Keller (1956) Zum Preisindex für die Lebenshaltung. Zur Kritik am Preisindex. *Wirtschaft und Statistik* 8, pp. 510-516.

Deutsche Bundesbank (1968) The Extent of Depreciation of Money since 1950, and the Prospective Trend of the Value of Money. Report Prepared by the Deutsche Bundesbank on 21 Juliy 1965 at the Request of the Federal Finance Court. *Monthly Report,* March, pp. 3-19.

Deutsche Bundesbank (1998) Problems of Inflation Measurement. *Monthly Report*, May, pp. 51-64.

Dhrymes, Phoebus J. (1971) Price and Quality Changes in Consumer Capital Goods: An Empirical Study. In: Zvi Griliches (ed.) *Price Indexes and Quality Change: Studies in New Methods of Measurement*, pp. 88-149. Cambridge/Mass.: Harvard University Press.

Diewert, W. Erwin (1976) Exact and Superlative Index Numbers. *Journal of Econometrics* 4, pp. 115-145.

Diewert, W. Erwin (1978) Superlative Index Numbers and Consistency in Aggregation. *Econometrica* 46, pp. 883-900.

Diewert, W. Erwin (1987) Index Numbers. In: *The New Palgrave. A Dictionary of Economics*, pp. 767-780. London: Macmillan, Vol. 2.

Diewert, W. Erwin (1988) *The Early History of Price Index Research.* NBER Working Paper No. 2713.

Diewert, W. Erwin (1995) Prepared Statement. In: *Consumer Price Index.* Hearings before the Committee on Finance. United States Senate, 104th Congress, pp. 115-118. Washington: U.S. Governement Printing Office.

Diewert, W. Erwin (1997) Comment. In: Timothy Bresnahan, Robert J. Gordon (eds.) *The Economics of New Goods.* Studies in Income and Wealth 58, pp. 423-433. Chicago: University of Chicago Press.

Diewert, W. Erwin (1998) Index Number Issues in the Consumer Price Index. *Journal of Economic Perspectives* 12, No. 1, pp. 47-58.

Eichhorn, Wolfgang et al. (eds.) (1978) *Theory and Applications of Economic Indices. Proceedings of an International Symposium Held at the University of Karlsruhe April-June 1976.* Würzburg: Physica.

Eichhorn, Wolfgang, and Joachim Voeller (1976) *Theory of the Price Index.* Berlin, Heidelberg, New York: Springer.

Eichmann, Wolfgang (1978) Die Berechnung des privaten Verbrauchs im Rahmen Volkswirtschaftlicher Gesamtrechnungen unter Berücksichtigung aller verfügbaren Quellen. In: Gerhard Fürst (ed.) *Grundlagen und Methoden der Verbrauchsstatistiken und der Konsumforschung*, pp. 55-76. Sonderheft 13 zum *Allgemeinen Statistischen Archiv.* Göttingen: Vandenhoeck & Ruprecht.

Elbel, Günther (1997) Zur Einführung Harmonisierter Verbraucherpreisindizes in Europa. *Wirtschaft und Statistik* 49, pp. 187-191.

Euler, Manfred (1974) Statistische Probleme bei der Erfassung des Verbrauchs an Nahrungs- und Genußmitteln in privaten Haushalten. *Wirtschaft und Statistik* 26, pp. 762-766.

Feenstra, Robert C. (1995) Exact Hedonic Price Indexes. *Review of Economics and Statistics* 77, pp. 634-653.

Fisher, Franklin M., and Zvi Griliches (1995) Aggregate Price Indices, New Goods, and Generics. *Quarterly Journal of Economics 110*, pp. 229-244.

Fisher, Franklin M., and Karl Shell (1968) Taste and Quality Change in the Pure Theory of the True Cost-of-Living Index. In J. N. Wolfe (ed.) *Value, Capital, and Growth.* Papers in Honour of Sir John Hicks. Edinburgh: Edinburgh University Press, pp. 97-139.

Fixler, Dennis (1993) The Consumer Price Index: Underlying Concepts and Caveats. *Monthly Labor Review 116*, No. 12, pp. 3-12.

Flaskämper, Paul (1928) *Theorie der Indexzahlen. Beitrag zur Logik des statistischen Vergleichs.* Berlin und Leipzig: Walter de Gruyter.

Forsyth, F. G., R. F. Fowler (1981) The Theory and Practice of Chain Price Index Numbers. *Journal of the Royal Statistical Society* A 144, pp. 224-246.

Fortin, Pierre (1990) Do We Measure Inflation Correctly? In: Richard G. Lipsey (ed.) *Zero Inflation: The Goal of Price Stability*, pp. 109-130. Policy Study 8. Toronto: C.D. Howe Institute.

Fürst, Gerhard (1960) Zur Aussagekraft von Preisindexziffern der Lebenshaltung. *Wirtschaft und Statistik* 12, pp. 5-8.

Fürst, Gerhard (1971) Was ist Menge, was ist Preis? Probleme der Deflationierung von Werten. *Allgemeines Statistisches Archiv* 55, pp. 10-22.

Fürst, Gerhard (ed.) (1976) *Messung der Kaufkraft des Geldes.* Sonderheft 10 zum Allgemeinen Statistischen Archiv. Göttingen: Vandenhoek & Ruprecht.

Fürst, Gerhard, Peter Deneffe (1952) Der neue Preisindex für die Lebenshaltung. *Wirtschaft und Statistik* 4, pp. 439-455.

Généreux, P. (1983) Impact of the Choice of Formulae on the Canadian Consumer Price Index. In: W. Erwin Diewert, C. Montmarquette (eds.) *Price Level Measurement. Proceedings from a Conference Sponsored by Statistics Canada*, pp. 489-511. Ottawa: Statistics Canada.

Glaab, Hans-Peter (1995) Anforderungen an harmonisierte Verbraucherpreisindizes. In: Statistisches Bundesamt (ed.) *Indizes - Status quo und europäische Zukunft.* Band 28 der Schriftenreihe Forum der Bundesstatistik. Stuttgart: Poeschel, pp. 88-98.

Gnoss, Roland (1995) Neue Ansätze zur Berechnung von Preisindizes - Eignen sich Hedonic-Indizes für die amtliche Statistik? In: Dietmar Harhoff, and Michael Müller (eds.) *Preismessung und technischer Fortschritt*, pp. 61-79. Baden-Baden: Nomos.

Gnoss, Roland, Bernd v. Minding et al. (1990) *Neue Ansätze zur Berechnung von Preisindizes. Empirische Analyse der sogenannten hedonic-Indizes zur Eliminierung der Qualitätskomponente bei der Berechnung von Preisdindizes am Beispiel von Computern.* Heft 13 der Schriftenreihe Ausgewählte Arbeitsunterlagen zur Bundestatistik. Wiesbaden: Statistisches Bundesamt.

Goldberger, Arthur S. (1968) The Interpretation and Estimation of Cobb-Douglas Functions. *Econometrica 36*, pp. 464-472.

Gordon, Robert J. (1990) *The Measurement of Durable Goods Prices*. Chicago: University of Chicago Press.

Gordon, Robert J. (1993) Measuring the Aggregate Price Level: Implications for Economic Performance and Policy. In: Kumiharu Shigehara (ed.) *Price Stabilization in the 1990s. Domestic and International Policy Requirements*, pp. 233-268. London: Macmillan.

Gorman, W.M. (1956) A Possible Procedure for Analysing Quality Differentials in the Egg Market. Published 1980 in the *Review of Economic Studies* 47, pp. 843-856.

Gottsmann, Wolfgang (1997) Harmonisierung der Verbraucherpreise. Auswirkungen auf die Durchführung der Preisstatistik in Sachsen. *Statistik in Sachsen* 3, Heft 2, pp. 23-27.

Greenspan, Alan (1997) *Problems of Price Measurement*. Center for Financial Studies. Frankfurt.

Griliches, Zvi (1961) Hedonic Price Indexes for Automobiles: An Econometric Analysis of Quality Change. In: U.S. Congress, Joint Economic Committee (ed.) *Government Price Statistics. Hearings Before the Subcommittee on Economic Statistics of the Joint Economic Committee. Congress of the United States*, pp. 173-196. Washington D.C.: Government Printing Office.

Griliches, Zvi (1971) Introduction: Hedonic Price Indexes Revisited. In: Zvi Griliches (ed.) *Price Indexes and Quality Change: Studies in New Methods of Measurement*, pp. 3-15. Cambridge/Mass.: Harvard University Press.

Griliches, Zvi (1994) Productivity, R&D, and the Data Constraint. *American Economic Review* 84, pp. 1-23.

Guckes, Siegfried (1964) Sonderrechnungen zum Preisindex für die Lebenshaltung und zur Statistik der Verbraucherpreise. *Wirtschaft und Statistik* 16, pp. 77-82.

Guckes, Siegfried (1976) Die Messung der Kaufkraft der privaten Verbraucher und die Berechnung von Kaufkraftparitäten im Statistischen Bundesamt. In: Gerhard Fürst (ed.) (1976) *Messung der Kaufkraft des Geldes*. Sonderheft 10 zum *Allgemeinen Statistischen Archiv*, pp. 23-45. Göttingen: Vandenhoek & Ruprecht.

Haberler, Gottfried (1927) *Der Sinn der Indexzahlen. Eine Untersuchung über den Begriff des Preisniveaus und die Methoden seiner Messung*. Tübingen: Verlag von J. C. B. Mohr.

Halvorsen, Robert, and Henry O. Pallakowski (1981) Choice of Functional Form for Hedonic Price Equations. *Journal of Urban Economics* 10, pp. 37-49.

Hansen, Bent, and Edward F. Lucas (1984) On the Accuracy of Index Numbers. *Review of Income and Wealth* 30, pp. 25-38.

Harhoff, Dietmar, and Dietmar Moch (1997) Price Indexes for PC Database Software and the Value of Code Compatibility. *Research Policy* 26, pp. 509-520.

Hausman, Jerry A. (1997a) Valuation of New Goods Under Perfect and Imperfect Competition. In: Timothy F. Bresnahan, and Robert J. Gordon (eds.) *The Economics of New Goods*. Studies in Income and Wealth 58, pp. 209-237. Chicago: University of Chicago Press.

Hausman, Jerry A. (1997b) Cellular Telephone, New Products and the CPI. NBER Working Paper 5982.

Hertel, Jürgen (1997) Einnahmen und Ausgaben der privaten Haushalte 1993. Ergebnis der Einkommens- und Verbrauchsstichprobe. *Wirtschaft und Statistik* 49, pp. 45-58.

Hicks, John R. (1940) The Valuation of the Social Income. *Economica N.S.* 7, pp. 105-124.

Hill, Peter (1988) Recent Developments in Index Numer Theory and Practice. *OECD Economic Studies* No. 10, pp. 123-148.

Hill, Peter (1993) Price and Volume Measures. In: Commission of the European Communities et al. (eds.) *System of National Accounts 1993*, pp. 379-406. Brussels.

Horstmann, Kurt (1963) Qualitätsänderungen und Preisindices. *Wirtschaft und Statistik* 15, pp. 594-599.

Hulten, Charles R. (1997) Quality Change in the CPI. *Federal Bank of St. Louis Review* 79, No. 3, pp. 87-100.

Kashyp, Anil K. (1995) Sticky Prices: New Evidence from Retail Catalogs. *Quarterly Journal of Economics* 110, pp. 245-274.

Kokoski, Mary F. (1993) Quality Adjustment of Price Indexes. *Monthly Labor Review* 116, No. 12, pp. 34-46.

Konüs, A. A. (1939) The Problem of the True Index of the Cost of Living. *Econometrica* 7, pp. 10-29.

Kortelainen, Mika (1997) *Index Bias in the CPI.* Bank of Finland Economics Department Working Paper 1/97.

Kroch, Eugene (1991) Tracking Inflation in the Service Sector. *Federal Reserve Bank of New York Quarterly Review* 16, Summer, pp. 30-35.

Kunz, Dietrich, and Manfred Euler (1972) Möglichkeiten und Grenzen der laufenden Wirtschaftsrechnungen. *Wirtschaft und Statistik* 24, pp. 321-326.

Lancaster, Kelvin J. (1966) A New Approach to Consumer Theory. *Journal of Political Economy* 74, pp. 132-157.

Lancaster, Kelvin J. (1977) The Measurement of Changes in Quality. *Review of Income and Wealth* 23, pp. 157-172.

Lange, Klaus (1979) *Eine Theorie der Preisstatistik - Preis, Preisrelationen, Preisindex.* Göttingen: Vandenhoeck & Ruprecht.

Lebow, David E., John M. Roberts, and David J. Stockton (1994) *Monetary Policy and „The Price Level"*. Board of Governors of the Federal Reserve System, Division of Research and Statistics.

Lequiller, Francois (1997) *Does the French Consumer Price Index Overstate Inflation?* INSEE Studies No. 2.

Liegey, Paul R. (1993) Adjusting Apparel Indexes in the Consumer Price Index for Quality Differences. In: Murray F. Foss, Marilyn E. Manser, and Allan H. Young (eds.) (1993) *Price Measurements and Their Uses*. NBER Studies in Income and Wealth 57, pp. 209-226. Chicago and London: University of Chicago Press.

Liegey, Paul R. (1994) Apparel Price Indexes: Effects of Hedonic Adjustment. *Monthly Labor Review* (May), pp. 38-45.

Lucas, Robert E. B. (1975) Hedonic Price Functions. *Economic Inquiry* 13, pp. 157-178.

Manser, Marilyn E., and Richard J. McDonald (1988) An Analysis of Substitution Bias in Measuring Inflation, 1959-1985. *Econometrica* 56, pp. 909-930.

Moch, Dietmar (1995) Ein hedonischer Preisindex für PC-Datenbanksoftware - Eine empirische Untersuchung. In: Dietmar Harhoff, and Michael Müller (eds.) *Preismessung und technischer Fortschritt*, pp. 81-107. Baden-Baden: Nomos.

Monopolkommission (1994) *Marktstruktur und Wettbewerb im Handel*. Sondergutachten 23. Baden-Baden: Nomos.

Moreau, Antoine (1996) Methodology of the Price Index for Microcomputers and Printers in France. In: OECD (ed.) *Industry Productivity. International Comparison and Measurement Issues.* OECD Proceedings. Paris: OECD, pp. 99-118.

Moulton, Brent R. (1993) Basic Components of the CPI: Estimation of Price Changes. *Monthly Labor Review 116*, No. 12, pp. 13-24.

Moulton, Brent R. (1995) Interarea Indexes of the Cost of Shelter Using Hedonic Quality Adjustment Techniques. *Journal of Econometrics 68*, pp. 181-204.

Moulton, Brent R. (1996) Bias in the Consumer Price Index: What Is the Evidence? *Journal of Economic Perspectives* 10, No. 4, pp. 159-177.

Moulton, Brent R., and Karin E. Moses (1997) Addressing the Quality Change Issue in the Consumer Price Index. *Brookings Papers on Economic Activity*, No. 1, pp. 305-349.

Muellbauer, John (1974) Household Production Theory, Quality, and the "Hedonic Technique". *American Economic Review* 64, pp. 977-994.

Muellbauer, John (1975) The Cost of Living and Taste and Quality Change. *Journal of Economic Theory* 10, pp. 269-283.

Nerlove, Marc (1995) Hedonic Price Functions and the Measurement of Preferences: The Case of Swedish Wine Consumers. *European Economic Review* 39, pp. 1697-1716.

Neubauer, Werner (1981) Preisindex der Lebenshaltung. In: *Handwörterbuch der Wirtschaftswissenschaften*, Vol. 6, pp. 213-222. Stuttgart: Gustav Fischer.

Neubauer, Werner (1995) *Konzeptionelle Vor- und Nachteile eines verketteten Verbraucherpreisindex*. Frankfurt am Main: Institut für Statistik und Mathematik, Fachbereich Wirtschaftswissenschaften, Johann Wolfgang Goethe-Universität Frankfurt am Main.

Neubauer, Werner (1996) *Preisstatistik*. München: Verlag Franz Vahlen.

Neves, Pedro Duarte, and Luís Morais Sarmento (1997) The Substitution Bias of the Consumer Price Index. *Banco de Portugal Economic Bulletin*, June, pp. 25-33.

Nicholson, J. L. (1967) The Measurement of Quality Changes. *Economic Journal* 77, pp. 512-530.

Nordhaus, William D. (1997) Do Real-Output and Real-Wage Measures Capture Reality? The History of Lighting Suggests Not. In: Timothy F. Bresnahan, and Robert J. Gordon (eds.) *The Economics of New Goods*. Studies in Income and Wealth 58, pp. 29-66. Chicago: University of Chicago Press.

Ohta, Makoto, and Zvi Griliches (1975) Automobile Prices Revisited: Extensions of the Hedonic Hypothesis. In: Nestor E. Terleckyj (ed): *Household Production and Consumption. NBER Studies in Income and Wealth* 40, pp. 325-390. New York: Columbia University Press.

Oliner, Stephen D. (1993) Constant-Quality Price Change, Depreciation, and Retirement of Mainframe Computers. In: Foss, Murray F., Marilyn E. Manser, and Allan H. Young (eds.) *Price Measurements and Their Uses*. NBER Studies in Income and Wealth, pp. 19-61. Chicago and London: University of Chicago Press.

Oulton, Nicholas (1995) Do UK Price Indexes Overstate Inflation? *National Institute Economic Review* 152, pp. 60-75.

Oulton, Nicholas (1998) The Implications of the Boskin Report. *National Institute Economic Review* 165, pp. 89-98.

Pollak, Robert A. (1971) *The Theory of the Cost-of-Living Index*. Bureau of Labor Statistics, Office of Prices and Living Conditions, Research Discussion Paper No. 11. Reprinted in: Robert A. Pollak (ed) (1989) *The Theory of the Cost-of-Living Index*, pp. 3-52. New York, Oxford: Oxford University Press.

Pollak, Robert A. (1983) The Treatment of "Quality" in the Cost-of-Living Index. *Journal of Public Economics 20*, pp. 25-53. Reprinted in: Robert A. Pollak (ed) (1989) *The Theory of the Cost-of-Living Index*, pp. 153-180. New York, Oxford: Oxford University Press.

Price Statistics Review Committee of the National Bureau of Economic Research (Dorothy S. Brady, Edward F. Denison, Irving B. Kravis, Philip J. McCarthy, Albert Rees, Richard Ruggles, Boris C. Swerling, and George J. Stigler) (1961) The Price Statistics of the Federal Government. Review, Appraisal, and Recommendations. A Report to the Office of Statistical Standards Bureau of the Budget. In: U.S. Congress, Joint Economic Committee (1961) *Government Price Statistics. Hearings Before the*

Subcommittee on Economic Statistics of the Joint Economic Committee. Congress of the United States, pp. 9-99. Washington D.C.: Government Printing Office.

Randolph, William C. (1988) Housing Depreciation and Aging Bias in the Consumer Price Index. *Journal of Business and Economic Statistics 6*, pp. 359-371.

Rees, Albert (1961) Alternative Retail Price Indexes for Selected Nondurable Goods, 1947-1959. In: U.S. Congress, Joint Economic Committee (ed.) *Government Price Statistics. Hearings Before the Subcommittee on Economic Statistics of the Joint Economic Committee. Congress of the United States*, pp. 137-172. Washington D.C.: Government Printing Office.

Reich, Utz-Peter, Philipp Sonntag, and Hans-Werner Holub (1977) *Arbeit-Konsum-Rechnung. Axiomatische Kritik und Erweiterung der Volkswirtschaftlichen Gesamtrechnung*. Köln: Bund-Verlag.

Reinsdorf, Marshall (1993) The Effect of Outlet Price Differentials on the U.S. Consumer Price Index. In: Murray F. Foss, Marilyn E. Manser, and Allan H. Young (eds.) *Price Measurements and Their Uses*. NBER Studies in Income and Wealth 57, pp. 227-254. Chicago and London: University of Chicago Press.

Reinsdorf, Marshall (1994) *Price Dispersion, Seller Substitution and the U.S. CPI*. Bureau of Labor Statistics, Working Paper 252.

Reinsdorf, Marshall B. (1998) Formula Bias and Within-Stratum Substitution Bias in the U.S. CPI. *Review of Economics and Statistics* 80 (1998), pp. 175-187.

Reinsdorf, Marshall, Paul Liegey, and Kenneth Stewart (1996) *Avoiding Downward Bias from Linking in the U.S. Consumer Price Index*. Mimeo, Bureau of Labor Statistics.

Riegel, Jürgen (1975) *Die Qualitätsänderung als preisstatistisches Problem*. Frankfurt/Main: Harri Deutsch.

Rothbarth, E. (1941) The Measurement of Changes in Real Income under Conditions of Rationing. *Review of Economic Studies* 8, pp. 100-107.

Samuelson, Paul A., and S. Swamy (1974) Invariant Economic Index Numbers and Canonical Duality: Survey and Synthesis. *American Economic Review* 64, pp. 566-593.

Santos, Emanuel, and Carlos Coimbra (1995) Automobile Prices and Quality Change. An Approach in Terms of Hedonic Prices. *Economic Bulletin*. Banco de Portugal, September, pp. 53-60.

Schmidt, Berndt (1997) *Der Preisindex für die Lebenshaltung aller privaten Haushalte in Gestalt eines Kettenindex. Beurteilung aus praktischer, empirischer und theoretischer Sicht*. Band 10 der Schriftenreihe zur Bundesstatistik. Stuttgart: Poeschel.

Shapiro, Matthew D., and David W. Wilcox (1996) Mismeasurement in the Consumer Price Index: An Evaluation. *NBER Macroeconomics Annual*, 94-142.

Shapiro, Matthew D., and David W. Wilcox (1997) Alternative Strategies for Aggregating Prices in the CPI. *Federal Reserve Bank of St. Louis Review* 79, no. 3, pp. 113-125.

Shiratsuka,Shigenori (1995a) Effects of Quality Changes on the Price Index: A Hedonic Approach to the Estimation of a Quality Adjusted Price Index for Personal Computers in Japan. *Bank of Japan Monetary and Economic Studies* 13, No. 1, pp. 17-52.

Shiratsuka,Shigenori (1995b) Automobile Prices and Quality Changes: A Hedonic Price Analysis of the Japanese Automobile Market. *Bank of Japan Monetary and Economic Studies* 13, No. 2, pp. 1-44.

Silver, Mick (1989) Consumer Price Indices and Parallel Markets. *The Statistician* 38, pp. 297-304.

Silver, Mick, and Christos Iaonnidis (1994) The Measurement of Inflation; Untimely Weights and Alternative Formulae: European Evidence. *The Statistician* 43, pp. 551-562.

Song, Wangqiu (1994) *Hedonic Regression Analysis in Consumer Price Index: Theory and Empirical Results.* Statistics Finland Studies No. 207. Helsinki: Statistics Finland.

Statistisches Bundesamt (1983) *Systematik der Einnahmen und Ausgaben der privaten Haushalte. Ausgabe 1983.* Stuttgart und Mainz: W. Kohlhammer.

Statistisches Bundesamt (1990) *Richtlinien zur Verbraucherpreisstatistik.* Vorläufige Fassung. Wiesbaden: Statistisches Bundesamt.

Statistisches Bundesamt (1996) *Vorschläge des Statistischen Bundesamts zur Umsetzung der Kommissionsverordnungen Mindestanforderungen für Verfahren der Qualitätsanpassung und Mindeststandards für die Preisermittlung.* Mimeo. Wiesbaden: Statistisches Bundesamt.

Szenzenstein, Johann (1995) Preisindizes für industrielle Güter in der amtlichen Statistik. In: Dietmar Harhoff, and Michael Müller (ed.) *Preismessung und technischer Fortschritt*, pp. 11-36. Baden-Baden: Nomos.

Szulc, Bohdan J. (1983) Linking Price Index Numbers. In: W. Erwin Diewert, and C. Montmarquette (eds.) *Price Level Measurement. Proceedings from a Conference Sponsored by Statistics Canada*, pp. 537-566. Ottawa: Statistics Canada.

Triplett, Jack E. (1971) Quality Bias in Price Indexes and New Methods of Quality Measurement. In: Zvi Griliches (ed.) *Price Indexes and Quality Change: Studies in New Methods of Measurement*, pp. 180-214. Cambridge/Mass.: Harvard University Press.

Triplett, Jack E. (1975) The Measurement of Inflation: A Survey of Research on the Accuracy of Price Indexes. In: Paul H. Earl (ed.) *Analysis of Inflation*, pp. 19-82. Lexington, Mass. et al.: Lexington Books.

Triplett, Jack E. (1986) The Economic Interpretation of Hedonic Methods. *Survey of Current Business* 66, No. 1, pp. 36-40.

Triplett, Jack E. (1987) Hedonic Functions and Hedonic Indexes. In: *The New Palgrave Dictionary of Economics*, Vol 2, pp. 630-634. New York: Macmillan.

Triplett, Jack E. (1989) Prices and Techological Change in a Capital Good: A Survey of Research on Computers. In: Dale W. Jorgenson, and Ralph Laundau (eds.) *Technology and Capital Formation*, pp. 127-213. Cambridge: MIT Press.

Triplett, Jack E. (1990) Hedonic Methods in Statistical Agency Environments: An Intellectual Biopsy. In: Ernst R. Berndt, and Jack E. Triplett (eds) *Fifty Years of Economic Measurement: The Jubilee of the Conference on Research in Income and Wealth. NBER Studies in Income and Wealth* 54, pp. 207-233. Chicago: University of Chicago Press.

Triplett, Jack E. (1997) Measuring Consumption: The Post-1973 Slowdown and the Research Issues. *Federal Reserve Bank of St. Louis Review* 79, no. 3, pp. 9-42.

Triplett, Jack E., and Richard J. McDonald (1977) Assessing the Quality Error in Output Measures: The Case of Refrigerators. *Review of Income and Wealth* 23, pp. 137-156.

Wynne, Mark A., and Fiona D. Sigalla (1996) A Survey of Measurement Biases in Price Indexes. *Journal of Economic Surveys* 10, pp. 55-89.

The following papers have so far been published:

May	1995	The Circulation of Deutsche Mark Abroad	Franz Seitz
June	1995	Methodology and technique for determining structural budget deficits	Gerhard Ziebarth
July	1995	The information content of derivatives for monetary policy – Implied volatilities and probabilities	Holger Neuhaus
August	1995	Das Produktionspotential in Ostdeutschland *	Thomas Westermann
January	1996	Sectoral Disaggregation of German M3	Vicky Read
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March	1996	The impact of interest rates on private consumption in Germany	Hermann-Josef Hansen
May	1996	Market Reaction to Changes in German Official Interest Rates	Daniel C. Hardy
May	1996	The role of wealth in money demand	Dieter Gerdesmeier

* Available in German only.

August	1996	Intergenerational redistribution through the public sector – Methodology of generational accounting and its empirical application to Germany	Stephan Boll
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October	1996	Alternative specifications of the German term structure and its information content regarding inflation	Sebastian T. Schich
November	1996	Enterprises' financing structure and their response to monetary policy stimuli An analysis based on the Deutsche Bundesbank's corporate balance sheet statistics	Elmar Stöss
January	1997	Reserve Requirements and Economic Stabilization	Ulrich Bindseil
June	1997	Direct investment and Germany as a business location	Thomas Jost
July	1997	Price Stability versus Low Inflation in Germany An Analysis of Costs and Benefits	Karl-Heinz Tödter Gerhard Ziebarth
October	1997	Estimating the German term structure	Sebastian T. Schich
October	1997	Inflation and Output in Germany: The Role of Inlation Expertations*	Jürgen Reckwerth
February	1998	Problems of Inflation Measurement in Germany	Johannes Hoffmann

* Forthcoming.