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*Session 1: Family of indices*

**Estimating the impact of government measures on the HICP
for the euro area and the EU**[1]

**Abstract**

In recent years developments in indirect taxes and administered prices have had a significant impact on euro area HICP inflation and were one factor behind the relative persistence of HICP inflation. Furthermore, they are important for the analysis of inflation in many of the EU countries. Against this background, Eurostat and the ECB have, in co-operation with National Statistical Institutes and National Central Banks in the EU, initiated work on two different measures of these effects: HICP at constant tax rates (HICP-CT) and estimates of administered price HICP. While different measures have existed in some EU countries for many years, this work aims at establishing estimates for the euro area and EU as a whole, using comparable standards. Following their implementation, these measures are expected to be a useful supplement to the existing set of HICP indices and special aggregates. The paper provides an overview of the definitions used, the borderline cases and the practices as well as some issues concerning piloting and implementation of these measures.

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## 1. General introduction

The examination of administered prices and indirect taxes and their effect on inflation is one of the recurrent issues when analysing HICP and forecasting inflation. These have been examined in recent years in the ECB Monthly Bulletin[2] based on first estimates constructed at the euro area level. Indirect taxes had a significant impact on euro area HICP inflation and administered prices were one factor behind the relative persistence of HICP inflation. However, both ex-post analyses as well as forecasting were hampered by the lack of a common approach and data at the national level.

In March 2003 the ECB presented at Eurostat's HICP Working Group [3] a user requirements paper [4] for the construction of harmonised measures of indirect taxes and administered price effects on HICP. Taking account of the higher priority given to the effect of indirect taxes, and due to the difficulty to define administered prices in a harmonised way, further work of Eurostat in collaboration with the ECB and the NSIs, focussed on the project of a constant-tax HICP (HICP-CT); this project has well advanced since then and it is described in the first part of this paper.

In parallel to this, the ECB initiated work on estimating the effect of administered prices on HICP in co-operation with the ECB's Working Group on General Economic Statistics (WGGES) [5]. The second part of this paper describes this project.

Both the HICP-CT and estimates for administered prices are work-in-progress. The information provided in this note is therefore provisional, and the first results presented are tentative. The purpose is to inform experts in the Ottawa Group and to gather their comments.

## 2. Constant tax HICP[6]

The subject of creating a harmonised constant tax rate index at EU level was discussed in various meetings of the HICP Working Group during 2003 and 2004. Based on a proposal made by the ECB and Eurostat, methodological issues were discussed and estimation methods developed. Following this methodological work, the actual implementation of the HICP-CT is being piloted during 2006.

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[2] See "The impact of developments in indirect taxes and administered prices on inflation" p. 27-28, ECB Monthly Bulletin, January 2004 or "Direct impact in administered prices and Indirect Taxes on euro area HICP developments", p. 35-36, ECB Monthly Bulletin, March 2003.

[3] Participants of the HICP Working Group are representatives of the EU Member States and of the ECB.

[4] Working Group "Harmonization of Consumer Price Indices", Item 9 "Measures of the impact of changes in indirect taxes and administered prices on HICPs", by the ECB, Luxembourg, 17-18 March 2003

[5] Members of the WGGES are experts of the EU-25 NCBs, as well as observers by Eurostat and the Bank for International Settlements (BIS).

[6] Acknowledgements are due to Lene Mejer (Eurostat) and Martin Eiglsperger (ECB) who actually wrote the methodological document on which the HICP-CT part of this paper is based

Even though the initiative of setting up a harmonised constant tax rate index at EU level was brought forward in recent years, the issue of adjusting consumer price indices for indirect taxes is not new and has been described in the ILO manual on consumer price indices of 1989 [7].

The experience of some Member States with similar indices provided an extremely useful input for the development of the HICP-CT [8]. The HICP Working Group acknowledged that identification of the exact tax coverage and the actual implementation was a major undertaking. Given this, work has been concentrated on the main taxes, and priorities for implementation were clarified. The methodological framework has been described to such a degree that it can function as guideline for setting up the index in each EU Member State.

This article defines the HICP at constant tax rates, surveys the coverage of the taxes and describes how to calculate the index. Finally, it touches on the planning for implementation in the EU Member States.

## 2.1   Definition and quality requirements

### Definition and use

The HICP-CT is defined as an index where tax rates are kept constant in the observation period compared to the reference period, i.e. through time. Hence, in the event of a tax rate change, the difference between the current HICP-CT and HICP would indicate the effect of the tax rate change on price changes assuming tax changes are passed on instantaneously and fully. It should be noted that the term 'rate' refers in this article to the tax *parameter;* a tax rate may be a certain percentage of the price, or an absolute tax amount levied on a physical unit.

The HICP is defined as a Laspeyres type index [9], measuring the price change of a basket of goods and services which households acquire for consumption [10]. To keep the following notation simple the focus is on index levels which reflect the price movement from a reference period $t_0$ (which is previous year's December) to an observation month $t_n$ within the current year so that linking factors could be ignored.

$$P_{t_0,t_n} = \sum_{i=1}^{g} \frac{p_{i,t_n}\left(\tau_{i,t_n}\right)}{p_{i,t_0}\left(\tau_{i,t_0}\right)} \cdot w_i \tag{1}$$

Given this, the HICP-CT is a Laspeyres price index which reflects the average change of $g$ item prices $p_{i,t}$ from the price reference period $t_0$ (which is previous year's December) to month $t_n$. The expenditure

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[7]   See Appendix 3 'Adjusting the CPI for indirect taxes' in 'Consumer price indices. An ILO manual' of 1989

[8]   INSEE, France, has provided useful insights into their index measuring 'underlying inflation' ('l'indice sous-jacent'). Equally the CPI team from the CBS, the Netherlands, has provided material for this document as well as useful discussions on the experience of the CBS in creating and maintaining their constant tax rate index ('afgeleide index'). In fact, the 'afgeleide index' corresponds to a large extent to the proposals set out by the ECB and Eurostat for an EU wide index.

[9]   Art. 9, Commission Regulation 2494/95

[10]   The formulae have been taken from de Haan, 1998, and adapted by the authors of the document HCPI 04/504.

shares which are used for weighting price relations are denoted as $w_i$. All product related taxes, which may be merged in vectors $\tau_{i,t}$, are part of the prices observed (and refer to the same periods as the prices).

The idea behind a constant tax rate index is to keep product related tax rates constant over time. The notation

$$_L CTP_{t_0,t_n} = \sum_{i=1}^{g} \frac{p_{i,t_n}\left(\tau_{i,t_0}\right)}{p_{i,t_0}\left(\tau_{i,t_0}\right)} \cdot w_i \qquad (2)$$

indicates that prices in $t_0$ and $t_n$ refer to the tax rates from the same period $t_0$. Whereas the prices $p_{i,t0}(\tau_{i,t0})$ are observable in the reference period $t_0$, the prices $p_{i,tn}(\tau_{i,t0})$ are not directly observable. They have to be calculated using the reporting period's purchaser prices $p_{i,tn}$, the product related tax rates $\tau_{i,tn}$ as well as the tax rates of the base period $\tau_{i,t0}$.

The use of the HICP-CT would not differ systematically from the use of other special aggregates of the HICP sub-indices and the influence of tax rate changes would be easy to see at sub-index level. The main use is for comparing percentage month-on-month index growth rates of the HICP and the HICP-CT. The difference of these two growth rates would indicate the impact of tax changes to the overall HICP inflation.

The same applies for the comparison of annual growth rates for the HICP and HICP-CT. In this case however (as in any other long-term comparison), the term 'constant-tax rate index' has a slightly different meaning, because for the HICP chain index the tax rates are to be updated for each new tax reference month December.

From equation (1) and (2), it appears that the analytical interest of the HICP-CT only materialises if it is compared with the HICP e.g.; where tax rate changes happen in the observation period, the effect of these changes on prices will be seen by comparing the HICP-CT with the HICP.

*Quality requirements and comparability*

The HICP-CT should be part of the 'family' of HICPs. It is therefore essential that it is exposed, as far as possible, to the same quality requirements as for the HICPs. As a consequence, the HICP-CT should provide information which is comparable from one EU country to another.

In practice, however, it will be necessary to strike a balance between completeness, feasibility and costs to produce the HICP-CT. Compromises as regards the treatment of taxes which have a negligible impact on the overall HICP (such as local taxes, or specific taxes levied on items with a low weight in the basket, e.g. sugar tax) seem acceptable.

Beyond this, tax structures in the present Member States show substantial differences. Therefore, it could be that different tax structures cause similar types of tax rate changes to have disparate effects on the HICP-CT. For example the following example could be considered [11]:

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[11] Thanks to Leendert Hoven for providing this example.

Suppose that country A applies an ad valorem tax on cigarette packets of 20 percent of the purchase price, and that the purchase price of a package of cigarettes equals 3 Euro in the reference period (the amount of tax per package equals 0.6 Euro). Country B applies a specific tax on cigarettes of 0.6 Euro per package. In a later period, the purchase price of a package of cigarettes goes up to 3.60 Euro (an increase of 20 percent). In country A the ad valorem tax rate is still 20 percent, and the amount of tax per package equals 0.72 Euro. In country B it was decided to raise the specific tax rate from 0.6 Euro to 0.72 Euro.

In country A, the HICP-CT would show a price rise of 20 percent for a package of cigarettes (the same as in the normal index, since there was no change in the tax rate), while in country B the HICP-CT would show a price rise of 16 percent for a package of cigarettes (which follows from applying the base period tax rate). So, while in both countries the effect on the amount of tax paid is the same, the resulting HICP-CTs differ. This is a consequence of applying taxes with different structural characteristics (e.g. an ad valorem tax as opposed to a specific tax) to the same product.

To avoid features of this kind an alternative to the HICP-CT methodology would have been to opt for the related method used by the CSO of Ireland which is based on the idea of keeping the amount (the effect) of taxes paid per product unit unchanged in their Constant Tax Price index. However, in the case of increasing pre-tax-prices this type of index takes into account that the amount of VAT and/or ad valorem tax paid per product unit increases even if the tax rates are not changed. In defining the HICP-CT as being dependent on tax rate changes, this feature has on purpose been avoided.

In fact, the HICP-CT has been designed as a constant tax rate index in order to satisfy the needs of the main user, namely the ECB, for monetary policy analysis.

## 2.2    Coverage of taxes

*Definition of tax coverage according to HICP framework and the European System of Accounts (ESA 1995)*

The HICP Working Group concluded that the relevant taxes are those that relate to final consumption expenditure. This section further develops which taxes in general should be taken into account by reference to the HICP coverage of goods and services as well as the European System of Accounts (ESA 1995).

The principle is that the coverage of the HICP-CT is exactly the same as the coverage for the HICP using the COICOP/HICP classification. Additionally it has been agreed to focus on those taxes which are directly related to the final consumption. On the other hand, taxes to be paid on intermediate stages (e.g. production, transport) should not be considered as relevant for a HICP-CT.

Other taxes paid by households, such as taxes on income and wealth cover compulsory and unrequited payments on income and wealth. For the HICP-CT, they are not relevant, since they are not included in

the coverage of the HICP [12]. These taxes reduce primary income and are not included in disposable income which is available for private consumption and saving. Changes in these taxes do not have a direct impact on the HICP and the private consumption deflator.

Subsidies might also be covered within the framework in theory; however their inclusion has been deferred pending future work.

The basic principle for considering which taxes are relevant is the concept of Household Final Monetary Consumption Expenditure (HFMCE) as adapted for the HICPs [13].

Distinction of taxes and fees

The difference between *taxes* and *administrative fees* is important for the HICP-CT, because administrative fees should be considered as administered prices and therefore not kept constant in an HICP-CT.

For the borderline cases between taxes and fees for the purchase of services from the government, the ESA 1995 gives the following criteria: "… if the licences are being granted automatically on payment of the amounts due, their payment is treated as taxes. But if the government uses the issue of licences to organise some proper regulatory function (such as checking the competence, or qualifications, of the person concerned), the payments made should be treated as purchases from government rather than payment of taxes, unless the payments are clearly out of all proportion to the cost of providing the services." [14]. Moreover according to ESA 1995 "driving or pilot's licences, television or radio licences, firearm licences, museum or library admissions, garbage disposal fees are treated in most cases as purchases of services rendered by government" [15].

Detailed definitions and borderline cases

As described above, it has been concluded that, in general, the 'Taxes on products' should be kept constant in the HICP-CT.

The relevance of the 'Taxes on products' subcategories has been analysed and discussed. The actual tax coverage of the HICP-CT is based on the recommendation of the HICP Working Group that 'the exact tax coverage should be worked out and a preference for concentrating on the main taxes was expressed'. Analysis shows that the main relevant taxes are the VAT contributions and the excise duties on particularly alcoholic beverages, tobacco and energy items (fuel, heating oil etc.). Also taxes on some specific items such as cars, insurances and entertainment are widely used within the EU.

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[12]  See point 18 in annexe 1b, of Council Regulation (EC) No. 1687/1998.

[13]  In fact there is a general issue on what is seen as a tax and a price for a product. With reference to Council Regulation 2494/95 (particularly art. 7), both in terms of coverage and valuation concept, then taxes linked to the purchase of a product are as a matter of principle included in the purchaser price and thereby covered by the HICP. Hence, a change in these taxes has an impact on inflation.

   See also annexes 1a and 1b of Council Regulation 1687/1998.

[14]  See ESA 1995, 4.79

[15]  See ESA 1995, 4.80

Taxes which are relevant for the HICP-CT

- 'Value added type taxes' (VAT) are included in the tax coverage of the HICP-CT given their definition: "A value added type tax (VAT) is a tax on goods or services collected in stages by enterprises and which is ultimately charged in full to the final purchasers" [16].

- Looking at the ESA 1995 category 'Taxes on imports, excluding VAT and import duties', only 'Excise duties' and 'Taxes on specific services' are relevant for the HICP-CT. In the context of imports, the distinction between import duties and taxes on imports has to be kept in mind. While import duties are not relevant for the HICP-CT (households rarely import consumer goods themselves although Internet shopping might change this gradually), taxes on imports, such as excise duties and general sales taxes, relate to the price of goods and services which the household pay. Hence 'Excise duties' as well as 'Taxes on specific services' are relevant.

- Regarding the ESA 1995 category 'Taxes on products, except VAT and import taxes', the situation is as follows:

  - 'Excise duties and consumption taxes', 'Car registration taxes' and 'Entertainment taxes' are covered by the HICP.

  - As regards insurances covered by the scope of the HICP then 'Taxes on insurance premiums' are in the tax coverage of HICP-CT. However, the service charge related to life insurance and to insurances taken out by owner occupiers is specifically excluded from COICOP/HICP 12.5 and hence these taxes are not covered.

  - 'Other taxes on specific services' would normally be in the HICP-CT coverage. Examples would be airport duties (taxes) or the toll paid for driving on motorways in some countries, - however these could also be seen as fees for a service rendered.

Taxes which are not relevant for the HICP-CT

- A number of taxes are not relevant because they can not be readily identified in relation to the end product/service. These are 'Import duties', 'Levies on imported agricultural products', 'Monetary compensatory amounts on imports', 'General sales taxes', 'Profits of import monopolies', 'General sales or turnover taxes', 'Profits of fiscal monopolies' and 'Export duties and monetary compensation amounts on exports'.

- 'Stamp taxes', 'Taxes on financial and capital transactions' could be considered not relevant under the assumption that these taxes relate to investments (capital taxes) and are hence out-of-scope of

the HICP. However, some parts of these categories could relate to final consumption expenditure, for example a fee/tax paid in relation to renting property.

- 'Taxes on lotteries, gambling and betting' are out of coverage because the relevant products/services are not included in the HFCME definition for HICPs.

<u>For other taxes, relevance should be investigated in each Member State</u>

- For other taxes, which are classified in the ESA 1995 under the category 'Other taxes on products, not elsewhere classified' the relevance for HICP should be investigated further in each Member State.

*Taxes set at different governmental levels*

Finally, a slightly different problem in relation to tax coverage of the HICP should be raised. This concerns taxes set at different governmental levels, e.g. at central, state, local or EU level for example. In a number of EU Member States, local/regional authorities have the right to set and collect taxes which are relevant in the HICP context. Consequently, these tax rates may be set at very different levels and changed randomly according to local/regional revenue needs. In theory they are within the scope of the HICP-CT but the practical difficulties in following the tax rate changes might hinder their actual inclusion.

Further to the above, it is proposed that local/regional relevant taxes should be excluded to the extent that the local/regional authorities have the right to define/set the tax themselves including setting the revenue level. If the local/regional power over setting and defining tax levels is limited to collecting tax revenues in relation to centrally fixed legislation and rules then the tax should be included in the HICP-CT coverage.

This point should be controlled when piloting the HICP-CT. For example, Member States which have a federal structure (as Belgium, Germany and Spain), but also Italy, might have quite extensive regional discretions for defining taxes and determining tax levels. However, for the purpose of the HICP-CT, if the tax revenue of these relevant taxes makes up a large proportion of the overall relevant taxes then their inclusion might be warranted. This could be a smaller problem than it sounds because the CPI samples in those countries would be based on regional samples.

*Tax coverage and relevance in Member States*

Care should be taken that similar types of taxes are included/excluded in the same way across countries. Similar in this context means how it is defined 'legally' and not economically, e.g. from a purchaser's point of view a fee in one country might be similar to a tax in another country; however only the tax would be relevant for the HICP-CT. Hence it is the definition of the tax which should be taken into

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[16] See SNA93, 7.63 and ESA95, 4.17

account for when it is decided whether or not to keep the respective tax constant in the HICP-CT and not its classification in the ESA 1995 terminology.

Some of the taxes which are relevant for the HICP would, in terms of tax revenue, be small and hence it would be unlikely that a tax rate change would influence the HICP.

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**The HICP-CT will keep constant:**

- **Any relevant tax which covers 2% or more of the total relevant taxes in the HICP and,**

- **in addition, a minimum of 90% total coverage of relevant taxes.**

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These criteria are defined in relation to the tax revenue of the relevant tax items and not in relation to the weight which each component makes up of total consumption (HFCME). The reason for this is that these definitions will facilitate the identification of relevant product taxes to be kept constant and thus the products can easily be identified at national level via the detailed product groups which are included in the HICP. A number of tests were done on the data in order to reach these criteria, but the pilot phase of the HICP-CT might refine these criteria further.

Hence, these criteria avoid complications caused by tax structures being different from one country to another and at the same time give assurance of a minimum coverage of 90% of the relevant taxes (please note that both criteria should be fulfilled).

Analysis shows that the number of relevant excise duties and consumption taxes is in general limited to well defined product/service groups per country.

## 2.3    Algebra and reference periods

*The algebra for the HICP-CT*

As outlined above, a Laspeyres type constant tax rate price index $_LCTP_{t0,tn}$ may be written as follows:

$$_LCTP_{t_0,t_n} = \sum_{i=1}^{g} \frac{p_{i,t_n}\left(\tau_{i,t_0}\right)}{p_{i,t_0}\left(\tau_{i,t_0}\right)} \cdot w_i ,$$    (2')

Where $p_{i,t}(\tau_{i,t0})$ denotes the constant tax rate price of item $i$ $(i=1,2,...,g)$ in period $t$ $(t=t_0,t_1,t_2,...,t_n)$. The vector $\tau_{i,t0}$ comprises product related taxes to be considered within the scope of a constant tax rate price index. For each item $i$ the vector $\tau_{i,t}$ generally comprises three tax rates: $\tau_{i,t} = (\alpha_{i,t}, \beta_{i,t}, \gamma_{i,t})$.

According to de Haan three types of taxes on products may be distinguished [17]:

$\alpha_{i,t}$:    tax levied at a constant rate (= fixed amount) per physical unit of item $i$ in period $t$ (specific tax), $\alpha_{i,t} \geq 0$;

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[17]    See de Haan, Jan: "Empirical studies on consumer price index construction", Voorburg/Heerlen 2000, p. 126.

$\beta_{i,t}$:  tax levied at a constant rate per monetary unit of the price of item $i$ in period $t$ (ad valorem tax), $\beta_{i,t} \geq 0$;

$\gamma_{i,t}$:  value added tax levied at a constant rate on the price for item $i$ in period $t$, $\gamma_{i,t} \geq 0$.

The sequence of taxes (i.e. what price an ad-valorem tax is levied on) may differ by type of product:

- The specific tax $\alpha_{i,t}$ may be levied before or after the ad valorem tax $\beta_{i,t}$.

- The ad valorem tax $\beta_{i,t}$ is levied either directly on the pre-tax price or on the pre-tax price plus the specific tax $\alpha_{i,t}$, or it is linked to the final purchaser price.

- The VAT $\gamma_{i,t}$ is levied on the pre-tax price plus all other taxes (the last tax to be applied) [18].

The exact sequence will have to be considered in each case. In order to show formulae reflecting practices of taxation, three possible cases are presented in annexe 1. However, other taxation rules may exist and the calculations would have to be done accordingly.

It can be seen from the three cases indicated in annexe 1 that the relative price movement keeping base period's tax rates constant depends not only on the changes in the pre-tax prices but also on the values of specific tax rates in the reference period or even on the ad valorem tax rate $\beta$ if it is levied on a price prior to a specific tax. However, the VAT rate has no influence. In other words, the choice of the constant tax reference period is neutral as regards the treatment of VAT, but the reference period matters for the treatment of specific taxes and sometimes for the treatment of ad valorem taxes other than VAT. [19]

So far the notation has been focused on price relations assuming that the tax rates to be kept constant stem from the price reference period (price reference period = tax rate reference period). This assumption should also be made to write down the formulae for an HICP at constant tax rates (HICP–CT). Taking previous year's December $(y,t_0)$ as base period to reflect the price movement from that period to concurrent year's reporting period $(y,t_n)$ this index is:

$$\text{HICP} - \text{CT}_{y,t_0;y,t_n} = \sum_{i=1}^{g} \frac{p_{i,y,t_n}\left(\tau_{i,y,t_0}\right)}{p_{i,y,t_0}\left(\tau_{i,y,t_0}\right)} \cdot w_{i,y}, \tag{8}$$

where $(y,t_0)$ denotes December in year y-1 being price and tax rate reference period for the index levels computed for the concurrent year y. The weights used for the compilation of these index levels are symbolised by $w_{i,y}$.

To provide notation for an HICP-CT covering time spans of several years y $(y=y_0,y_1,y_2,...,y_m)$ the set of periods per year should comprise 13 months: $t_0,t_1,...,t_n,..., t_{12}$ so that each period of time is specified by two parameters: $y_j$ and $t_k$ with j=1,2,...,m and k=0,1,2,...,12.

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[18]  The specific tax is levied first – and not after the VAT.

[19]  The relative price movement keeping base period's tax rates constant depends only on the changes in the pre-tax prices and on the values of specific tax rates in the reference period if all proportional taxes relate to prices **including specific taxes** (see cases 1 and 3 in annexe 1). If alternatively a proportional tax is directly related to the pre-tax price, and a specific tax is applied afterwards, then the rate of the proportional tax will become relevant (see case 2 in annexe 1).

$$\text{HICP} - \text{CT}_{y_0,t_0;y_m,t_n} = \sum_{i=1}^{g} \frac{p_{i,y_0,t_{12}}\left(\tau_{i,y_0,t_{12}}\right)}{p_{i,y_0,t_0}\left(\tau_{i,y_0,t_0}\right)} \cdot w_{i,y_0} \cdot \sum_{i=1}^{g} \frac{p_{i,y_1,t_{12}}\left(\tau_{i,y_1,t_{12}}\right)}{p_{i,y_1,t_0}\left(\tau_{i,y_1,t_0}\right)} \cdot w_{i,y_1} \cdot$$
$$\dots \cdot \sum_{i=1}^{g} \frac{p_{i,y_m,t_n}\left(\tau_{i,y_m,t_n}\right)}{p_{i,y_m,t_0}\left(\tau_{i,y_m,t_0}\right)} \cdot w_{i,y_m}$$

(9)

Equation (9) indicates that "chaining effects" in a HICP-CT following the above outlined concept appear not only due to using up-dated weights but also in the case when specific tax rates have been changed.

*Reference periods*

The HICP-CT should be chained at the end of every year according to the same method as used for the HICPs. From an analytical point of view, the impact of tax rate changes as the difference between the HICP and the HICP-CT can only be evaluated if the weights in the two indices are identical.

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|---|---|
| **Weighting reference period:** | **same as for HICP (period ending no more than 7 years before preceding December)** |
| **Tax reference period:** | **December of previous year** |
| **Price reference period:** | **same as for HICP (= December of previous year)** |
| **Index reference period:** | **same as for HICP (2005 = 100)** |

Within the algebra developed above, the tax rates to be kept constant should be taken from December of each previous year. This means that the price reference period (of HICP and HICP-CT) and the tax rate reference period (of HICP-CT) would be identical. Consequently, HICP and HICP-CT could be compiled in the same way and exactly the same weights can be used. These weights reflect the actual expenditure shares of the weight reference period, price-updated to previous year's December. Hence, they show also changes in product related taxes which may have appeared since the former weighting structure has been used.

Differences between the HICP and the HICP-CT appear only to be due to different tax rates relied on in both indices because the same weights are used. Additionally, the impact of yearly up-dating the weights is the same in the HICP and the HICP-CT. Both could be regarded as an advantage in terms of interpretation. On the other hand, it may be seen as a disadvantage that due to yearly up-dating of the tax reference period the specific tax rates of each past year's December have an impact on HICP-CT levels.

Finally, a note on new taxes: As the HICP-CT is a price index for the same goods and services as covered by the HICP, regardless of the product related taxes which are levied on them, the inclusion of new taxes will not pose any problem, at least in theory [20]. Whenever a new relevant tax is introduced, the pre-tax price for the observation period has to exclude this tax for the current year, i.e. the tax will be kept constant at 0 for the current year. From the following year onwards, the tax rate of previous year's December will be used.

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[20] It has to be acknowledged that the practical aspects of identifying new relevant taxes are not negligible.

## 2.4    Implementation

*Timing of implementation and dissemination*

The piloting of the index is taking place during 2006 in most EU Member States. In fact, pilot projects have been launched in 17 EU Member States (Belgium, Czech Republic, Denmark, Germany, Estonia, Greece, Spain, Cyprus, Lithuania, Luxembourg, Malta, Austria, Poland, Portugal, Slovakia, Sweden and the UK) and are partly funded by Eurostat. Six more Member States (France, Hungary, Ireland, Latvia, the Netherlands and Finland) with existing similar projects will provide largely comparable information. The two other EU Member States (Slovenia and Italy) are also ready to join in soon.

By the end of 2006, HICP-CTs should be available from most EU Member States as from January 2003 onwards. A thorough evaluation of all the information, tax coverage and indices, will start in 2006 and go on during 2007.

It is hoped that all Member States would be in a position to provide HICP-CTs in 2007 on a regular basis. Prior to any large scale dissemination of the HICP-CT at European level, the quality will be thoroughly evaluated by the HICP Working Group.

*Tax coverage, and level of detail required for calculation*

The tax coverage should be investigated in each Member State. Results will be evaluated by the HICP Working Group in order to assure comparability.

At the HICP WG meeting in December 2003, the level of detail necessary for distinguishing different tax rates was touched. In practical terms, COICOP-4-digits level could be regarded as sufficient with respect to the precision of a HICP-CT. Different tax rates or even tax types within a 4-digit aggregate may be treated by computing appropriate averages.

For example in France, an estimate of the tax rate for a group of products is carried out when the necessary detail for making exact adjustment is not available within the classification.

Also the ONS applies such estimations for computing its "core" retail price index (RPIY) as "… it is impossible to remove tax levels from every individual price since, in some cases, the relevant information is not collected. For example, to remove tax from the price of a particular alcoholic drink requires the alcoholic content to be known, but this is not collected by ONS. Instead, an estimate of average alcohol content is calculated for each item, and the relevant tax rate applied." [21].

On the other had, it would be most accurate to calculate pre-tax prices from each purchaser price and to carry out the full HICP-CT index calculations as for the HICP.

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[21]    'Consumer Price Indices – Technical Manual', 2005 Edition, p. 85

*Sub-indices*

In line with ECB user requirements it is planned that the HICP-CT is provided by the all-item HICP-CT, supplemented by breakdowns into the following main components:

- HICP-CT Goods
  - HICP-CT Un-processed food
  - HICP-CT Processed food
  - HICP-CP Non-energy industrial goods
  - HICP-CT Energy
- HICP-CT Services

## 3. Administered prices

In the ECB the statistical work on administered prices started in early 2003. At that time the ECB calculated some initial estimates of euro area administered prices based on HICP data at the euro area level. The selection of the items subject to some sort of administration or regulation was done by assuming that at the euro area level some items were administered in all or most countries. The items selected included goods and services such as water supply, refuse collection, education, medical services and other items for which regulation is known to be in force in most euro area countries.

Furthermore, the issue of regulated prices has also been studied in the context of the Eurosystem Inflation Persistence Network (IPN). Lünnemann and Marthä[22] (2005) showed that regulated prices tend to lead to nominal price rigidity, particularly downward, and, at the same time, to less frequent but larger price changes. Their study as well was based on the second-best solution of a selection of a common subset of HICP sub-indices for all (at that time) EU 15 Member States.

Apart from the effect in euro area HICPs – which is used by the ECB to define price stability at euro area level and is therefore its key policy variable – the discussions underlined that the analyses of administered price developments for individual EU countries is a priority for users. In particular, the economic developments in the new EU Member States and the role that changes in administered prices have played in these countries are a reason to develop EU country estimates as well.

More detailed work on administered prices started in the ECB in May 2005. Discussions with the EU-25 National Central Banks (NCBs) lead to an agreed target definition of administered prices. Based on this NCBs provided a selection of HICP sub-indices which correspond to the definition. Some borderline cases where identified and further discussed in order to have a standardised conceptual framework and implementation across countries. First estimates for national and euro area administered prices HICP

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[22] "Regulated and services' prices and inflation persistence", by Patrick Lünnemann and Thomas Y. Mathä, ECB Working Paper NO. 466, April 2005

were compiled. Final estimates are planned for the second half of 2006. It is also intended to present this work to the NSIs in the context of the HICP Working Group in the second half of 2006.

## 3.1 General approach

The work on administered prices contained two main elements: the first – and most difficult part – was the definition of administered prices and the identification of administered price components in the national HICPs. The second - relatively straightforward part – was the compilation of aggregated HICP measures for administered prices. The compilation of such aggregates entailed first a clear understanding and agreement on a common definition of administered prices. The discussions on the definition were carried out keeping in mind the operational aspects of it.

Though administered prices are frequently analysed and reported in publications, there are only few references to it in standard publications by NSIs, and administered prices are not discussed in the international CPI manual released in 2004. For illustration, in the euro area the Statistisches Bundesamt compiles a monthly CPI sub-index for administered prices and an overall CPI excluding administered prices. They are compiled from detailed CPI information, which is not published for the HICP. The definition follows a measure compiled by the Sachverständigenrat (Council of Economic Advisors). The latter sub-divides the index into four sub-groups for administered prices: (1) directly administered price index, where prices are directly set by the government (e.g. TV licence fees); (2) partly administered price index, where the government can influence price developments (e.g. telephone tariffs); (3) quasi-administered prices of goods and services that are subject to special consumption taxes (e.g. alcohol) and (4) indirectly administered prices for agricultural products subject to national or European regulations (e.g. butter). Istat, the Italian national statistical institute, also publishes CPI sub-indices of regulated and non regulated services based on detailed CPI data. The regulated services are in Italy split between the locally regulated (e.g. refuse collection tariffs, public transportation by road) and the nationally regulated services (e.g. railway transportation, postal services).

The chosen definition of "administered prices" does not aim at estimating the full "administration" content in the overall HICP. This would require a detailed knowledge of price setting and market structures. It would also require estimating not only the direct impact of administrative measures on HICP, but also the indirect effects that – via wages and producer prices – determine the total consumer price effect

The HICP coverage is defined as all goods and services bought by households in actual monetary transactions in the country, notwithstanding their nationality, residence, income or other socio-economic status. This coverage derives from the concept of "household final monetary consumption expenditure" of the European System of Accounts (ESA 95). The prices measured by the HICPs are the prices actually paid by the households to purchase individual goods and services. These include all taxes less subsidies on products. Goods and services provided by government to individual households as social transfers in kind (e.g. health and education) are not reflected in the HICP. However, so-called "out-of-the pocket"

expenditure by households, as well as price shares to be paid by the consumer for goods and services as transfers in kind, are included in the HICP.

## 3.2 Definition of administered prices

Numerous forms of 'administration' influence the HICP and there is probably no item covered by the HICP that are not affected by any administrative measures, at general, regional or local level. For this reason it was important to focus the definition on the "mainly" administered items. Furthermore, the definition serves as a guidance and conventions need to be accepted in order to separate between administered and not administered prices. In fact, there are some "grey" areas in the administered price definition with do not allow for a clear-cut selection of administered items. The three main issues that need to be defined and distinguished are (a) administered prices, (b) regulated prices and (c) indirect taxes and excise duties.

The following definition was agreed by the ECB's Working Group on General Economic Statistics in 2005 after discussion with NCBs, ECB users and Eurostat.

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**Administered prices** cover all goods and services the prices of which are *fully* ("directly") set or *mainly* ("to a significant extent") influenced by the government (central, regional, local government or national regulators).

**Fully administered prices** cover the prices of goods and services directly set by the government. For example, the government may choose to increase local public transportation charges at regular intervals. Other examples may include education fees, theatre tickets, refuse collection, childcare, fees for administrative documents.

**Mainly administered prices** cover the prices of goods and services on which the government or national regulatory authorities have a significant influence. For example, these may include in particular prices which require approval/permission by national regulatory authorities for their change. The influence of the national regulator's decisions could be direct on retail prices or indirect via wholesale prices. However, it must have a clear and significant impact on consumer prices.

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## Supplementary explanations and conventions

**Covered in this definition of administered prices are:**

- Price changes approved by government and other national supervisory authorities. This is the case in particular for network industries (e.g. telecommunication services by fixed line providers or postal services) and insurance prices in some countries; the supervisory authority's decisions shall

be explicitly taken with the objective to influence consumer prices, although these may only be indirectly affected through changes in producer prices;

- The effects of restriction in the consumer price level (price caps/price floors), if binding;
- The effects of "permanent" (e.g. long-term) restrictions on consumer price changes;
- Social rents offered at subsidised price level to, for example, low-income households;
- Household fixed out-of-the-pocket expenditures for health, education and social services (e.g. a household pays a fixed amount of 10 euro for a medical visit) covered in the HICP basket.

**Not covered in above definition of administered prices are:**

- Consumer prices subject to indirect taxation and excise duties (i.e. prices of goods and services with a high indirect tax component (e.g. tobacco, petrol)). These cases are excluded as their effect will be reflected in Eurostat's Constant Tax Price HICP that will be released from 2006;
- The effects of product regulation such as safety or environmental standards (e.g. safety standards for cars). These cases are excluded as their effect on consumer prices is extremely difficult to determine and almost all goods and services are subject to some regulation;
- Prices subject to the Common Agricultural Policy in the EU.
- Index linked prices, unless the reference indicator for linking is an administered price. For example, the linking of rent changes and changes of insurance gross premiums to the overall HICP/CPI, or to other price indices, or the linking of gas price changes to the change of oil prices, should normally not be considered as an administered price, as they are contractual agreements that aim at simplifying price adjustments rather than government control of price changes;
- The effects of "transitory" restrictions for consumer price changes, i.e. restrictions which are not "permanent" (e.g. restrictions in place in some countries around the time of the euro changeover).

The inclusions and exclusions on the above definition mainly pertain to the borderline cases discussed below. However, in some cases, such as the prices subject to the EU Common Agricultural policy or the effects of product regulation, the exclusion was driven by the fact that these regulations mainly have an influence on intermediate goods and services and therefore their impact is very difficult to be identified. Additional considerations regarding the impact of a regulation on consumer prices were also taken into account during the implementation phase. In some cases, in fact, some form of mild regulation exists (e.g. price approval of a government supervisory authority) which has no identifiable impact on consumer prices.

### 3.3   Borderline cases

In addition, the following borderline cases had to be decided:

*Taxes and excise duties*

In the final definition, indirect taxes and excise duties are not considered, with the exception when these represent the "price" for a government services (e.g. taxes for refuse collection) or when the tax is used by the Government to "regulate" or moderate the actual price development. This is, for example, the case of petrol prices in some countries. The main reason for not including heavily taxed items in the definition was the user requirement to distinguish between this relatively small number of items which may have at occasions very significant and identifiable impact on HICP changes (e.g. when tobacco or fuel taxes change) and the more comprehensive and heterogeneous group of all administered items, which impact is much more difficult to identify and monitor at the euro area level. Furthermore, the effect of indirect taxes will be captured by the HICP constant tax index developed by Eurostat. However, it should be noted that there are different measurement objectives and compilation practices. While the HICP CT project will measure the development of inflation *at constant tax rates*, the administered price index is a sub-index of the HICP.

*Health, education and social services*

A further borderline case regarded the expenditures of households for health, education and social services if households pay only a part of the full price (e.g. a household pays a fixed amount of 5 euro for medical products, while most of the costs are covered by social insurance as transfer in kind). In this case, it is not the producers or retailers selling price that is administered, but the amount the household pay 'out-of-the-pocket'. The so-called "out-of-the pocket" expenditure by households, as well as price shares to be paid by the consumer for goods and services as transfers in kind, are included in the HICP. These are considered "mainly administered" if this out-of pocket expenditure is either a price fraction paid of the full price, or if the full price is paid only if the item as such is administered. In fact, part of this out-of-the-pocket expenditure includes the payment of items which have regular market prices (e.g. drugs or medical visits not reimbursed by the social insurance).

*Effects of regulator decisions on prices*

A very important component of the administered prices as mentioned above are the subcomponents of regulated prices for network industries, and further HICP categories (e.g. insurance). Price regulation in this field has often the objective to mimic the outcome of a competitive market, or to stimulate its emergence (e.g. after market deregulation). Depending on national circumstances there may be regulation at a retailer level (e.g. government supervisory authority admission needed for changing final consumer prices), and/or the regulation may refer to the prices charged at the wholesaler level (e.g. for the infrastructure to be offered by the former monopolists to new competitors). It was decided to consider these consumer services as possible components of the administered prices sub-index.[23]

The argument had also been put forward that if the regulatory authority is in some way 'independent' from the government, the effect of their decisions on prices should not be considered administered. The

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[23]  See also European Central Bank, "Price effects of regulatory reform in selected network industries", March 2001.

convention adopted by the ECB covers this group of prices in the sub-component 'mainly administered' prices. While there may exist a certain operational independence of the regulator from the government, it is the government that sets the regulator's mandate, objectives and instruments. Provided the influence of the regulator on prices and in particular on price changes can be considered significant, it is therefore decided to cover prices which are subject to the approval of a regulator authority – whether or not this is part of the government sector - in the mainly administered price component.

### *Regulation against exorbitant price increases*

Most countries have for some markets regulations that aim to protect consumers against exorbitant price increases for sitting tenants. Rents are perhaps the most relevant example (e.g. '*rents must not increase by more than 40% in 3 years*'). While this is, in principle, a restriction of price changes, it effectively does not limit 'normal' rent price changes and is unlikely to have a strong impact on changes of aggregate rent price indices. It is therefore proposed to treat rents as not-administered if the only existing form of regulation refers to consumer protection against exorbitant price increases, unless it can be shown that there have been recent periods in which these rules had a significant impact on aggregate price indices.

### *Regulation limiting the dispersion of consumer prices*

In the case of rents there exist regulations that limit the price dispersion of individual rents without regulating the changes in the aggregate price level (e.g. '*individual rents must not deviate more than 30% from average rent of dwelling with similar characteristics*'). A different form of restricting dispersion of consumer prices are the existing rules that impose for a specific product offer an identical retail price in all retail outlets (e.g. for books). However, there is no regulation that limits the increase of the average rent level or changes in the specific book prices. These items are therefore treated as non-administered if the only existing form of regulation refers to limiting price dispersion of retail prices.

## 3.4 Compilation of national and euro area aggregates

It was decided that the ECB would compile national and euro area estimates in order to ensure a standardised approach. For the implementation mainly the level of detail to be used in the compilation was examined as well as the way to include any changes in the administered items. Basis for all compilations are the sub-indices and weights for HICPs as provided by Eurostat.

### *Level of detail for compilation*

The HICPs are available at the level of 4-digit COICOP/HICP breakdown. These 93 sub-indices are for some HICP sub-categories not detailed enough for making a separation into administered and other prices. For example, the HICP rent component is not available in a breakdown by different type of rental contracts (private/social). For this reason, the provisional estimate of the national HICP administered prices was compiled based on an agreed threshold used to select the sub-indices with a mixed composition of both administered and non administered prices. These sub-indices were included in the administered price aggregate when composed of regulated prices for products whose expenditure weight

is more than 50% of the sub-index. It is planned to further explore the possibility to compile administered prices for countries which publish HICP or CPI data with more details. Furthermore, Eurostat's work on the expansion of the HICP classification to the 5th and 6th COICOP/HICP level would, if successful, help to overcome this issue.

*Compilation formula and changes in the administered items*

Consumer goods and services may become administered or may be deregulated over time. As we could see from the available information provided by the NCBs, such changes have not often happen. Nevertheless, a user requirement is that the administered price time series should contain at each point in time only those items which are considered administered at the time. In line with the HICP chain index formula, changes in the administered price composition are introduced on an annual basis in January. The new data for the year including the changes is then linked to the December of the previous year. In this way the aggregation of administered and non-administered prices to the overall HICP is preserved with no discrepancy.

*Backdata*

Given the changes in HICP coverage in 2000 and 2001, that affected in particular (administered) health, education and social services prices, it was decided to start compiling administered price series from 2001. From this date, HICP data are also available from all new EU Member States.

## 3.5 First results of the administered price HICP for the euro area.

The HICP categories subject to administered prices belong to both goods and services and vary across countries. Special cases were discussed in the WGGES in order to have a common understanding and treatment of them in the compilation practices. Further work on differences in the application of the definition by NCBs will improve these estimates. A brief description of the selection of administered items in the euro area is provided below (data was collected for all 25 EU Member States but not further discussed here). Following the selection of national administered components euro area aggregates weights and indices have been compiled as explained above. The provisional estimates for the euro area results are shown below in table 1 and Chart 1 and 2.

As shown in the table, based on these preliminary results, the share at the euro area level reaches 15.4% of the total HICP. It is particularly striking to see the small share of fully administered prices (3.5%), which is mainly due to the relative small number and weight of items that correspond to the above definition (e.g. water supply, refuse and sewerage collection in several countries), while most administered items are only partially influenced by Government or regulatory authorities, and some of these have a significant weight in the HICP (e.g. rents, energy items and telecommunication services).

**Table 1. HICP – Euro area administered price expenditure shares (%) and description**

|  | **Administered prices** | **Fully administered** | **Mainly administered** |
|---|---|---|---|
| **Share in 2006** | **15.4** | **3.5** | **11.9** |
| **Description of varying national sub-indices included in the compilation of euro area administered prices** | Actual rentals (COICOP/HICP 04.1.1_2)<br>Water supply (COICOP/HICP 04.4.1)<br>Refuse collection (04.4.2)<br>Sewerage collection (04.4.3)<br>Electricity (COICOP/HICP 04.5.1)<br>Gas (04.5.2)<br>Heat energy (04.5.5)<br>Medical products (COICOP/HICP 06.1.1 and 06.1.2_3)<br>Medical and paramedical services (COICOP/HICP 06.2.1_3)<br>Dental services (COICOP/HICP 06.2.2)<br>Hospital services (COICOP/HICP 06.3)<br>Passenger transport services by railway (COICOP/HICP 0.7.3.1)<br>Passenger transport services by railway by road (COICOP/HICP 0.7.3.2)<br>passenger transport by air (COICOP/HICP 07.3.3)<br>Passenger transport by sea (COICOP/HICP 07.3.4)<br>Other services in respect to personal transport equipment (COICOP/HICP 07.2.4, including toll and parking facilities as well as driving lessons and licences)<br>Postal services prices (COICOP/HICP 08.1)<br>Telephone and telefax services (COICOP/HICP 08.3)<br>Recreational and sporting services (COICOP/HICP 09.4.1)<br>Cultural services (COICOP/HICP 09.4.2)<br>Canteens (COICOP/HICP 11.1.2)<br>Education prices (COICOP/HICP 10.0)<br>Social protection prices (COICOP/HICP 12.4)<br>Other services n.e.c. (COICOP/HICP 12.7) |  |  |

Source: ECB calculations based on information by the WGGES and Eurostat HICP data.

**Chart 1**. **Euro area HICPs - administered and non-administered prices** (annual percentage changes)
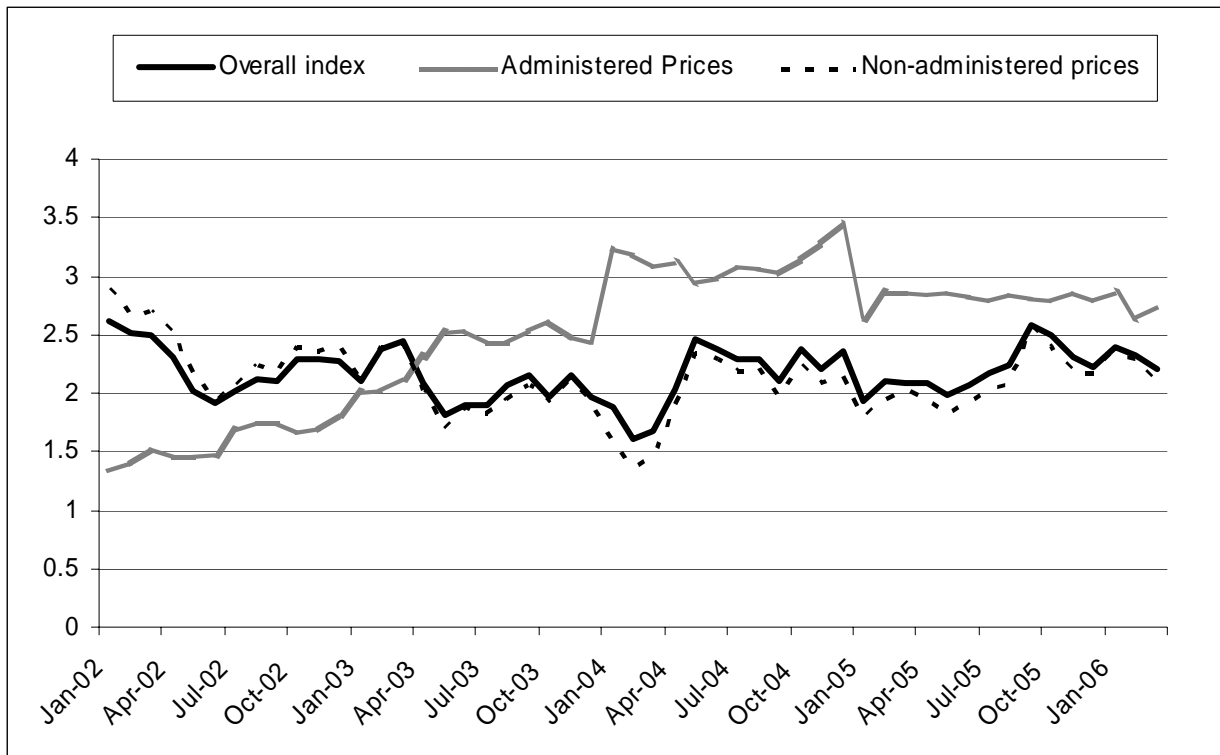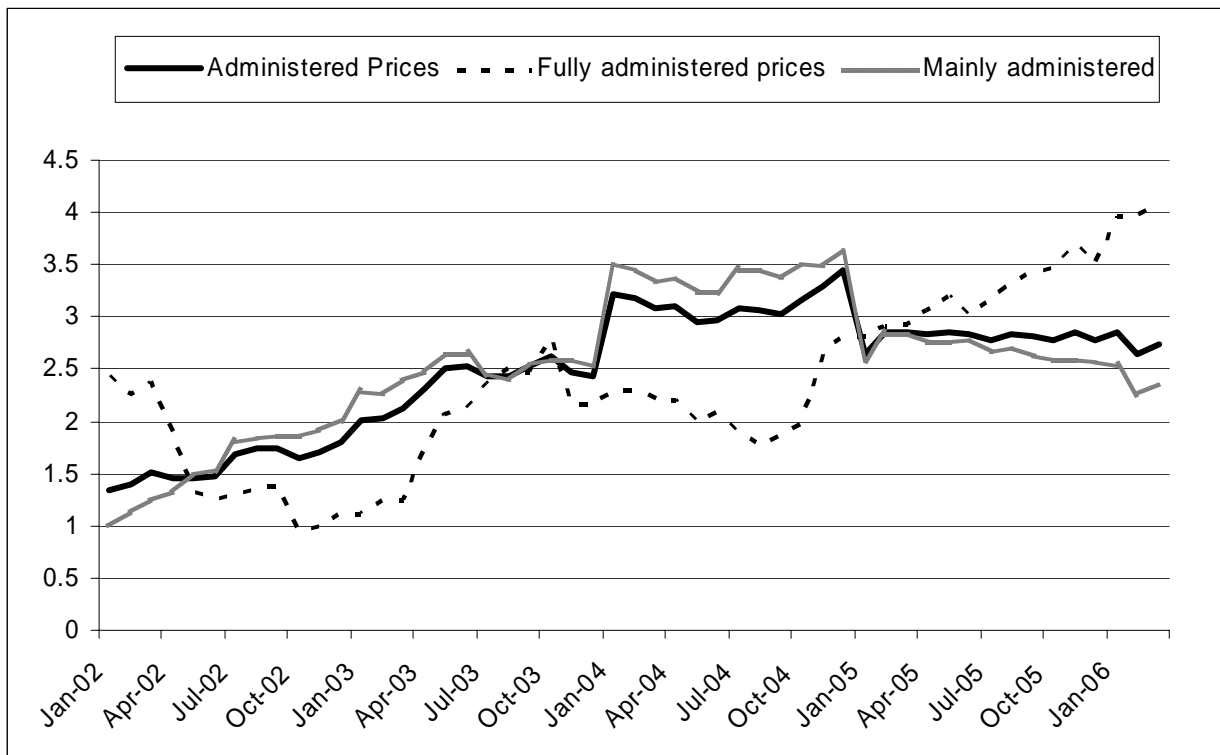


**Chart 2**. **Euro area HICPs - Fully and mainly administered prices** (annual percentage changes)



Source: ECB calculations based on information by the WGGES and Eurostat HICP data.

Annual increases of administered prices in the euro area have been continuously above the all item HICP inflation since the second quarter of 2003. This reflects a similar situation in particular in Germany, Ireland, Netherlands and Austria. There is in particular a peak in January 2004 due to the component of mainly administered items, influenced by the German medical goods and services prices which have been subject to a reform starting in 2004.

Altogether, administered prices have a small impact on consumer inflation at the euro level. This is mainly due to their relative weight (around 15% of total) and to the fact the impact is smoothed being the euro area the result of a weighted average of country results. For individual countries, the effect is at time significantly higher.

## 3.6   Planned follow-up

The estimates for administered prices in the HICP of the euro area and EU countries still need some refinement in terms of changes of the coverage of the administered price components in past years, which has not yet been implemented. Furthermore, some further discussion on specific items (e.g. rents) and other national issues will take place regarding the selection of administered prices. In addition, the examination of the possible use of more detailed national price indices where available will be explored in order to improve the accuracy of the calculations. This work is expected to be finalised in 2006.

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## Annexe 1 – 3 examples on Sequence of Taxes

| *Case 1* |
|---|

Sequence of taxes:

- the ad valorem tax $\beta_{i,t}$ is levied on the pre-tax price plus the specific tax $\alpha_{i,t}$, [24]

- the VAT $\gamma_{i,t}$ is levied on the pre-tax price plus all other taxes (the VAT is the last tax to be applied).

The purchaser price $p_{i,t}$ to be paid for an item $i$ in period $t$ may be written as follows:

$$p_{i,t} = \widetilde{p}_{i,t} + \alpha_{i,t} + \beta_{i,t}(\widetilde{p}_{i,t} + \alpha_{i,t}) + \gamma_{i,t}\left[\widetilde{p}_{i,t} + \alpha_{i,t} + \beta_{i,t}(\widetilde{p}_{i,t} + \alpha_{i,t})\right], \text{[25]} \tag{A.1}$$

where $\widetilde{p}_{i,t}$ denotes the pre-tax price of item $i$ in period $t$, which is the price excluding product related taxes.

From formula (A.1) it follows that:

$$p_{i,t} = (1 + \gamma_{i,t})(1 + \beta_{i,t})(\widetilde{p}_{i,t} + \alpha_{i,t}). \tag{A.2}$$

Solving this for $\widetilde{p}_{i,t}$, the pre-tax price of a product is defined as:

$$\widetilde{p}_{i,t} = \frac{p_{i,t}}{(1 + \gamma_{i,t})(1 + \beta_{i,t})} - \alpha_{i,t}. \tag{A.3}$$

And the constant tax rate price $^{ct}p_{i,tn}$, i.e. the (not observable) price of item $i$ in the reporting period $t_n$ which would have appeared if the reference period's ($t_0$'s) tax rates had been in force can be calculated as:

$$p_{i,t_n}(\tau_{i,t_0}) = (1 + \gamma_{i,t_0})(1 + \beta_{i,t_0})(\widetilde{p}_{i,t} + \alpha_{i,t_0}) \tag{A.4}$$

Given this and referring to formula (2) the price relation which reflects the relative price movement of item $i$ from $t_0$ to $t_n$ is:

$$\frac{p_{i,t_n}(\tau_{i,t_0})}{p_{i,t_0}(\tau_{i,t_0})} = \frac{(1 + \gamma_{i,t_0})(1 + \beta_{i,t_0})(\widetilde{p}_{i,t} + \alpha_{i,t_0})}{(1 + \gamma_{i,t_0})(1 + \beta_{i,t_0})(\widetilde{p}_{i,t_0} + \alpha_{i,t_0})} = \frac{\widetilde{p}_{i,t_n} + \alpha_{i,t_0}}{\widetilde{p}_{i,t_0} + \alpha_{i,t_0}} \tag{A.5}$$

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[24]  The specific tax is levied after part of the proportional taxes.

[25]  There are several other ways to define an equation which relates the purchaser price of an item to its product related taxes and its pre-tax price. De Haan (l.c., p. 126)

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*Case 2*

Sequence of taxes:

- the ad valorem tax $\beta_{i,t}$ is levied on the pre-tax price,

- the VAT $\gamma_{i,t}$ is levied on the pre-tax price plus all other taxes (the VAT is the last tax to be applied).

The purchaser price $p_{i,t}$ to be paid for an item $i$ in period $t$ may be written as follows:

$$p_{i,t} = \widetilde{p}_{i,t} + \alpha_{i,t} + \beta_{i,t}\widetilde{p}_{i,t} + \gamma_{i,t}\left(\widetilde{p}_{i,t} + \alpha_{i,t} + \beta_{i,t}\widetilde{p}_{i,t}\right) \qquad (A.1')$$

where $\widetilde{p}_{i,t}$ denotes the pre-tax price of item $i$ in period $t$, which is the price excluding product related taxes.

From formula (A.1') it follows that:

$$\begin{aligned} p_{i,t} &= \left(1+\gamma_{i,t}\right)\left(\widetilde{p}_{i,t} + \alpha_{i,t} + \beta_{i,t}\widetilde{p}_{i,t}\right) \\ &= \left(1+\gamma_{i,t}\right)\left(1+\beta_{i,t}\right)\widetilde{p}_{i,t} + \left(1+\gamma_{i,t}\right)\alpha_{i,t} \end{aligned} \qquad (A.2')$$

Solving this for $\widetilde{p}_{i,t}$, the pre-tax price of a product is defined as:

$$\widetilde{p}_{i,t} = \frac{p_{i,t}}{\left(1+\gamma_{i,t}\right)\left(1+\beta_{i,t}\right)} - \frac{\alpha_{i,t}}{\left(1+\beta_{i,t}\right)} \qquad (A.3')$$

And the constant tax rate price $^{ct}p_{i,tn}$, i.e. the (not observable) price of item $i$ in the reporting period $t_n$ which would have appeared if the reference period's ($t_0$'s) tax rates had been in force can be calculated as:

$$p_{i,t_n}\left(\tau_{i,t_0}\right) = \left(1+\gamma_{i,t_0}\right)\left(\widetilde{p}_{i,t} + \alpha_{i,t_0} + \beta_{i,t_0}\widetilde{p}_{i,t}\right) \qquad (A.4')$$

Given this and referring to formula (2) the price relation which reflects the relative price movement of item $i$ from $t_0$ to $t_n$ is:

$$\frac{p_{i,t_n}\left(\tau_{i,t_0}\right)}{p_{i,t_0}\left(\tau_{i,t_0}\right)} = \frac{\left(1+\gamma_{i,t_0}\right)\left(\widetilde{p}_{i,t_n} + \alpha_{i,t_0} + \beta_{i,t_0}\widetilde{p}_{i,t_n}\right)}{\left(1+\gamma_{i,t_0}\right)\left(\widetilde{p}_{i,t_0} + \alpha_{i,t_0} + \beta_{i,t_0}\widetilde{p}_{i,t_0}\right)} = \frac{\left(\widetilde{p}_{i,t_n} + \alpha_{i,t_0} + \beta_{i,t_0}\widetilde{p}_{i,t_n}\right)}{\left(\widetilde{p}_{i,t_0} + \alpha_{i,t_0} + \beta_{i,t_0}\widetilde{p}_{i,t_0}\right)} \qquad (A.5')$$

This case could be described with the same formula as case 1. Then, the specific tax rate $\alpha'$ would be defined as $\alpha/(1+\beta)$. This means that any change of the ad valorem tax $\beta$ would imply a change of the specific tax $\alpha'$. The price relation (A.5') becomes:

$$\frac{p_{i,t_n}\left(\tau_{i,t_0}\right)}{p_{i,t_0}\left(\tau_{i,t_0}\right)} = \frac{\left(1+\gamma_{i,t_0}\right)\left(1+\beta_{i,t_0}\right)\left(\widetilde{p}_{i,t} + \alpha'_{i,t_0}\right)}{\left(1+\gamma_{i,t_0}\right)\left(1+\beta_{i,t_0}\right)\left(\widetilde{p}_{i,t_0} + \alpha'_{i,t_0}\right)} = \frac{\widetilde{p}_{i,t_n} + \alpha'_{i,t_0}}{\widetilde{p}_{i,t_0} + \alpha'_{i,t_0}} \qquad (A.6')$$

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**Case 3**

Sequence of taxes:

- the ad valorem tax $\beta_{i,t}$ is linked to the final purchaser price [26],

- the VAT $\gamma_{i,t}$ is levied on the pre-tax price plus all other taxes (the VAT is the last tax to be applied, even though it has some impact on the ad valorem tax).

The purchaser price $p_{i,t}$ to be paid for an item $i$ in period $t$ may be written as follows:

$$p_{i,t} = \widetilde{p}_{i,t} + \alpha_{i,t} + \beta_{i,t} p_{i,t} + \gamma_{i,t}\left(\widetilde{p}_{i,t} + \alpha_{i,t} + \beta_{i,t} p_{i,t}\right) \tag{A.1''}$$

where $\widetilde{p}_{i,t}$ denotes the pre-tax price of item $i$ in period $t$, which is the price excluding product related taxes.

Solving (A.1'') for $p_{i,t}$ this becomes:

$$p_{i,t} = \left(\widetilde{p}_{i,t} + \alpha_{i,t}\right)\left(1 + \gamma_{i,t}\right) + \beta_{i,t} p_{i,t}\left(1 + \gamma_{i,t}\right) = \frac{\left(\widetilde{p}_{i,t} + \alpha_{i,t}\right)\left(1 + \gamma_{i,t}\right)}{1 - \beta_{i,t}\left(1 + \gamma_{i,t}\right)} \tag{A.2''}$$

Accordingly, the pre-tax price $\widetilde{p}_{i,t}$ is:

$$\widetilde{p}_{i,t} = \frac{p_{i,t}\left\{1 - \beta_{i,t}\left(1 + \gamma_{i,t}\right)\right\}}{\left(1 + \gamma_{i,t}\right)} - \alpha_{i,t}. \tag{A.3''}$$

And the constant tax rate price $^{ct}p_{i,tn}$, i.e. the (not observable) price of item $i$ in the reporting period $t_n$ which would have appeared if the reference period's ($t_0$'s) tax rates had been in force can be calculated as:

$$p_{i,t_n}\left(\tau_{i,t_0}\right) = \frac{\left(p_{i,t_n} + \alpha_{i,t_0}\right)\left(1 + \gamma_{i,t_0}\right)}{\left\{1 - \beta_{i,t_0}\left(1 + \gamma_{i,t_0}\right)\right\}} \tag{A.4''}$$

Given this and referring to formula (2) the price relation which reflects the relative price movement of item $i$ from $t_0$ to $t_n$ is:

$$\frac{p_{i,t_n}\left(\tau_{i,t_0}\right)}{p_{i,t_0}\left(\tau_{i,t_0}\right)} = \frac{\left(\widetilde{p}_{i,t_n} + \alpha_{i,t_0}\right)\left(1 + \gamma_{i,t_0}\right)}{1 - \beta_{i,t_0}\left(1 + \gamma_{i,t_0}\right)} \Bigg/ \frac{\left(\widetilde{p}_{i,t_0} + \alpha_{i,t_0}\right)\left(1 + \gamma_{i,t_0}\right)}{1 - \beta_{i,t_0}\left(1 + \gamma_{i,t_0}\right)} = \frac{\widetilde{p}_{i,t_n} + \alpha_{i,t_0}}{\widetilde{p}_{i,t_0} + \alpha_{i,t_0}} \tag{A.5''}$$

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[26]  It is quite common to relate ad valorem tax rates on tobacco products directly to the purchaser price.

Comparing this ad valorem tax linked to the final purchaser price to the ad valorem tax linked to the pre-tax price including specific taxes (case 1), this implies that any VAT rate change results implicitly in a change of the ad valorem tax (if it was applied as in case 1).

In fact, when an ad valorem tax is linked to the final purchase price, a VAT rate change has a higher impact then if the ad valorem tax was linked to the pre-tax price.