Price and Quantity Trends in the Pharmaceutical Benefits Scheme

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1. Introduction

Most pharmaceuticals in Australia are provided under the Pharmaceuticals Benefits Scheme (PBS) administered by the Commonwealth Department of Health and Aging through the Health Insurance Commission (HIC). The scheme is financed primarily from a budgetary allocation of the Commonwealth Government.

Over the past few years, the cost of the PBS has increased at over 10% per annum and this has lead to various actions to curb this. While the cost of new "blockbuster" drugs have been highlighted from time to time, lately attention has turned to reducing the number of drugs prescribed by doctors.

An earlier paper[1] identified some of the factors contributing to the increased cost of pharmaceuticals under the PBS such as the prices of new and existing drugs, the demand for drugs, and the increase in the number of people able to access drugs at concessional rates. It concluded that while prices of new drugs are generally higher than those for older drugs, the principal driver of increased cost was the strong rise in demand, which was offset to some extent by declining prices. Case studies[2] of specific classes of drugs within the PBS have also pointed to declining prices over time.

This paper describes the underlying trends in the prices of and demand for drugs listed under the PBS using a variety of indexes of price and quantity suggested by the index number literature. It calculates indexes for all drugs in aggregate and for different disease categories.

Section 2 outlines the reference pricing system used by the PBS in setting both the initial and subsequent prices for drugs, while Section 3 describes the various types of index that researchers have developed to compare how prices and quantities change over time.

Section 4 reports the results of applying these indexes to a database of drugs provided under the PBS over the 11-year period 1991-92 to 2001-02. It examines how the indexes vary among disease categories and how this reflects the operations of the PBS reference pricing system. Some conclusions about the way price and quantity indexes for PBS drugs should be calculated are discussed in Section 5 as well as some of the limitations of the analysis and how it might be improved.

The analysis undertaken in this paper is based on a database provided by the Pharmaceutical Access and Quality (PAQ) Branch of the Department of Health and Aged Care. The database covers the period 1991-92 to 2001-02 and consists of annual script and cost data for each brand of most drugs supplied under the PBS, as well as its molecular name. To this has been added the drug's Anatomical Therapeutic Classification (ATC) code as set out in the PBS Schedule database.[3]

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[1] Sweeny 2002b.
[2] Sweeny 2002a.
[3] The author would like to thank Peter Marlton of the PAQ Branch and John Abrams of the PBS Branch of the Department of Health and Aged Care for their assistance in providing this data and guidance in its use and interpretation.

2. The Pharmaceutical Benefits Scheme Pricing System

The Pharmaceutical Benefits Scheme subsidises the cost to the Australian public of over 600 different drugs in a variety of forms and strengths. The Pharmaceutical Benefits Scheme is administered by the Commonwealth Department of Health and Ageing (DHA). The Pharmaceutical Benefits Advisory Committee (PBAC) is the body that recommends whether a drug should be listed on the PBS, while the Pharmaceutical Benefits Pricing Authority (PBPA) recommends to the Department the price at which it should be listed.[4]

In response to a range of queries and complaints about the nature and transparency of the procedures for listing and pricing drugs, the PBPA has provided an outline of these processes – its "Procedures and Methods", the latest edition of which is for March 2003 (PBPA 2003).

Since 1993, suppliers proposing to have a new product listed on the PBS are required to provide a range of information including the cost of the new drug and its proposed price, as well as an economic evaluation in order for the PBAC to "compare the cost arising from the new drug with the benefits gained from its use compared to existing therapy". "New drugs are most commonly recommended by the PBAC on the basis of cost minimisation or acceptable incremental cost effectiveness ratios".

In addition to this, the PBPA uses additional information on overseas prices (UK and NZ), prices of alternatives listed on PBS, and expected expenditure to recommend a price for the new drug. The price is then negotiated between DHA and the supplier.

All drugs listed on the PBS are reviewed at least once per year. For this purpose, drugs used to treat the same condition or which have a similar action are grouped in therapeutic sub groups according to their Anatomical Therapeutic Classification (ATC). All drugs within a sub group are reviewed together.

The principal method used to determine drugs prices is Therapeutic Group Pricing described by PBPA as follows:

> *"Where drugs are considered to be of similar safety and efficacy, the lowest priced brand or drug sets the benchmark price for either the other brands of that drug or the other drugs within the same therapeutic group. Pricing within these therapeutic groups is based on the therapeutic relativities between drugs as noted on the therapeutic relativity sheets... If a sponsor demonstrates to the PBAC a clinical advantage for a particular drug over alternative products then that drug may be granted a higher subsidised price over the alternative."*

Reference pricing, of which therapeutic group pricing is a variant, is increasingly used in many jurisdictions to set the price of drugs. Most commonly however it covers the first instance describe above, namely the comparison of a particular brand to other brands of the same drug. Australia is almost alone among countries in including brands of other drugs in the same therapeutic group in the comparison.

In addition to these pricing methods, the PBPA sometimes negotiates price/volume arrangements for new drugs when unit prices are relatively high and there is potential for high demand or demand is uncertain. This may also occur when restrictions on

[4] Further information on PBS pricing and listing procedures is provided in PBPA 2003, Sweeny 2002 and Salkeld, Mitchell, and Hill 1998.

drugs already listed are relaxed or the indications for the drug are widened. Under this arrangement, unit prices fall as volume increases

3. Price and Quantity Indexes

Serious academic studies of pharmaceutical prices and quantities span at least 40 years and have often involved the use of indexes, the construction of which has been the source of much discussion, partly because pharmaceuticals are a good example of a product subject to significant changes in quality and also because new drugs are constantly being introduced and old drugs being withdrawn from the market.[5]

Indexes provide a useful way of summarising prices or quantities to avoid having to compare many different individual prices or quantities. They can be compiled at different levels of aggregation – for the whole of the market, for different therapeutic categories, for different conditions and for different types of drugs.

Indexes such as the Consumer Price Index and National Account price deflators have important uses in a variety of policy and other contexts so a substantial body of literature has developed proposing alternative ways of calculating them and discussing how well their properties are suited to specific uses.[6]

Studies of pharmaceuticals have been done both temporally, to see how prices and quantities have changed over time, and spatially, to examine the differences in prices and consumption patterns among countries. This paper is concerned solely with temporal indexes[7] which compare "averages" in one period with "averages in another period. The difference among indexes is in the way the "average" is calculated.

3.1 Direct Price Index Formulae[8]

Direct indexes are averages comparing prices in a base period 0 with those in another period t and are constructed using data on the prices, p_{it}, p_{i0} and quantities, q_{it}, q_{i0} of a common set of products $i = 1$ *to* n.

Price and quantity relatives between periods 0 and T are defined as:

Price relative $= \frac{p_{it}}{p_{i0}}$, and Quantity relative $= \frac{q_{it}}{q_{i0}}$

The simplest way of calculating a price index is to take an average of the price relatives between two periods, i.e.:

$$\frac{1}{n} \times \sum_i \frac{p_{it}}{p_{i0}}$$

Because this index gives equal weight to each product within the common set it is only used when quantity or expenditure weights are unavailable. Most other indexes

[5] Recent examples of index calculations for pharmaceuticals include Berndt et al. 1998, Busch et al. 2001, Frank et al. 1999.
[6] Useful reviews of types of index number, their properties and their application in temporal comparisons are Johnson 1996, Diewert 1993, Diewert 1995, ILO 2003.
[7] Spatial comparisons of Australia with other countries are reported in Sweeny 2003.
[8] Quantity indexes are defined in analogous fashion to price indexes. Their formulae are set out in Appendix 1.

calculate weighted averages of prices using quantity or expenditure shares to reflect the relative importance of each product within the set.

The most widely used price indexes are the **Laspeyres** (L) index which uses quantity weights in a base period 0 and the **Paasche** (P) indexes which uses quantity weights in the current period:

$$L_t = \frac{\sum_i p_{it}.q_{i0}}{\sum_i p_{i0}.q_{i0}}$$

$$P_t = \frac{\sum_i p_{it}.q_{it}}{\sum_i p_{i0}.q_{it}}$$

The Laspeyres index is widely used because it is easy to calculate and quantity data are often only available for a particular period (the base period). It is also more easily understandable as it measures the change in value of a fixed basket of goods over time. While other indexes have the same goods in the basket, their proportions change over time so quantity weights are required for each period. The Laspeyres indexes suffer from the fact that the quantity weights usually become increasingly unrepresentative of consumption patterns the further the current year is from the base period.

The Laspeyres and Paasche indexes ignore any substitution effects that arise when prices vary between periods and therefore form upper and lower bounds respectively for relative price indexes. Over time the Laspeyres index usually grows faster than the Paasche index.

The Fisher (F), Walsh (W), Tornqvist (T) and Vartia (V) indexes are the most commonly used alternatives to the Laspeyres and Paasche indexes and they seek to utilise all the price and quantity information available, in particular they give equal weight to the quantity weights in both periods (and are thus symmetric indexes). They are defined as follows:

$$F_t = \sqrt{L_t \cdot P_t}$$

$$W_t = \frac{\sum_i p_{it}.\sqrt{q_{it} \cdot q_{i0}}}{\sum_i p_{i0}.\sqrt{q_{it} \cdot q_{i0}}}$$

$$T_t = \prod_i (p_{it} / p_{i0})^{\frac{1}{2}(w_{i0}+w_{it})} \text{, or } \ln T_t = \frac{1}{2}\sum_i [(w_{it} + w_{i0}).\ln(p_{it} / p_{i0})]$$

$$V_t = \prod_i (p_{it} / p_{i0})^{W_i} \text{ , or } \ln V_t = \sum_i W_i \cdot \ln(p_{it} / p_{i0})]$$

where:

$$w_{it} = p_{it}.q_{it} / \sum_i p_{it}.q_{it}$$

$$W_i = \frac{(p_{it}.q_{it} - p_{i0}.q_{i0}) / (\ln(p_{it}.q_{it}) - \ln(p_{i0}.q_{i0}))}{(\sum_i p_{it}.q_{it} - \sum_i p_{i0}.q_{i0}) / (\ln(\sum_i p_{it}.q_{it}) - \ln(\sum_i p_{i0}.q_{i0}))}$$

The literature on indexes has specified a number of conditions for an ideal index (I), but none of the above indexes fully satisfies them.[9]

The *time reversal test* requires that for periods a and b:

$$I_{ab} = \frac{1}{I_{ba}}$$

The Fischer, Tornqvist and Vartia indexes satisfy this condition, but the Laspeyres and Paasche indexes do not.

An important condition is *transitivity*, namely that for periods $a<b<c$:

$$I_{ac} = I_{ab}.I_{bc}$$

The Laspeyres and Paasche indexes do not satisfy this condition, while the Fisher, Tornqvist and Vartia indexes satisfy it approximately.

Consistency in aggregation requires that indexes calculated from aggregated data are the same as those calculated from disaggregated data. The Laspeyres, Paasche and Vartia indexes are consistent in aggregation while the Fisher and Tornqvist are approximately so.

The Fisher and Tornqvist indexes are *superlative* as defined by Diewert (1976), in that they are consistent with a theoretic index based on microeconomic theory. However the production and consumption of pharmaceuticals has a number of features that are at variance with standard neoclassical theory. In particular

- In many instances, prices for drugs under patent are only weakly linked to cost of manufacture and the strength of the link will vary from drug to drug
- Most drugs are designed for treating either one or a small number of diseases, so substitutability among drugs is limited
- Demand for drugs is typically price inelastic, with perceived therapeutic worth being the most important determinant

3.2 Chained Price Indexes

Direct price indexes use a common set of products which can become increasingly unrepresentative over time as new products enter the marketplace and old products disappear. A lot of research has been done on how new products and quality change in existing products should be handled in calculating indexes.[10] Most of the problems associated with this and the drawbacks of the various direct indexes can be overcome by the use of chaining.

In a chained index the current period t is compared to the previous period t-1 for all periods, rather than comparing each period to a fixed base period. Chaining can be applied to any of the direct price indexes discussed earlier.

The chained index comparing periods t-1 and t uses the set of goods common to both period t-1 and t. In general this will be a different set of goods to the one

[9] A useful summary of conditions satisfied by various indexes is given in Johnson 1996.
[10] ILO 2003.

common to period t and t+1, because this latter comparison will include goods that are new in period t, whereas the former comparison will not.

Despite this, new goods enter more quickly into the index calculation and the disparity between the Laspeyres and Paasche indexes becomes much less.

The direct index between period t-1 and t represents the percentage change between t-1 and t so the index relative to a base period can be calculated by successively applying this percentage change to the previous index starting with the initial comparison between period 0 and 1, as follows:

$$I_{01} = C_{01}$$

$$I_{02} = I_{01}.C_{12}$$

$$I_{03} = I_{02}.C_{23}$$

to

$$I_{0t} = I_{0t-1}.C_{t-1t}$$

where C_{t-1t} is the chained index between period t-1 and t.

While chained indexes can be misleading when prices and quantities fluctuate significantly rather than follow trends, this is unlikely to be the case for drugs available under the PBS. There seems to be increasing agreement among index number commentators in favour of either the chained Fisher or Tornqvist index in temporal comparisons.

4. PBS Price and Quantity Indexes

Drugs are uniquely defined by a chemical (or molecule) name but may come in a range of different strengths, forms and pack sizes. Each of these different combinations, as well as any variations in diseases for which they are prescribed and other restrictions, has a specific item code within the PBS Schedule. Within each item code there maybe a number of different brands marketed by competing suppliers of the drug. Each molecule therefore can appear with multiple item codes within the PBS Schedule.

The dataset provided by the Department of Health and Aged Care reports the cost to the government and the cost to the patient of each item/brand combination provided under the PBS, as well as the number of prescriptions filled by pharmacists for each of these drugs. Total cost was calculated by adding patient and government cost and is equivalent to total retail expenditure on these drugs. The price of each drug was obtained by dividing the total cost by the number of scripts, where scripts are taken as the measure of quantity.[11]

This dataset was then utilized at three levels of aggregation in determining price and quantity indexes:

- At the brand level, utilizing all the data (6296 observations)
- At the item level, aggregating across brands (2965 observations)

[11] Some of the records in the dataset did not specify a supplier. If this was the only record for an item, the record was retained. If there was one other supplier the record was combined with the record for that supplier. Otherwise the data in the record was allocated proportionately to the other suppliers.

- At the molecule level, aggregating across all combinations (812 observations)

4.1 Price Indexes

The chained price indexes calculated for these three collections of data are reported in Tables B1 to B3 in Appendix B and shown graphically in Figures B1 to B3.

As expected from the index literature, the Laspeyres and Paasche price indexes form upper and lower bounds and the other symmetric indexes track within these bounds, and have very similar profiles.

All indexes at the three different levels of aggregation demonstrate rising pharmaceutical prices for the period 1991-92 to 1995-96, followed by steadily declining prices thereafter. The decline is more pronounced for the brand and item level indexes, with prices in 2001-02 below those in 1991-92. When calculated at the molecule level, the indexes show a milder decline with prices in 2001-02 being comparable to those in 1992-93.

The gap between the Laspeyres and Paasche indexes is relatively constant after 1995-96 at the brand and item level, but at the molecule level the gap is wider and increases over time.

The indexes calculated at the brand and item levels are very similar, because PBS pricing methods ensure that price variations among brands within an item are very small. Originator brands can be sold at a markup to the base price but this tends to be a relatively small percent and is fairly constant over time.

At the molecule level different strengths, forms and pack sizes are aggregated. If higher strength forms become more important over time, this requires less scripts to be written if pack sizes are unchanged. This may therefore understate quantity and hence overstate price increases.

Figure 1 below compares the Fisher index calculated for the three levels of aggregation with the price deflator for private consumption expenditure from the Australian National Accounts compiled by the Australian Bureau of Statistics. This latter index is a good indicator of price movements for the whole range of products consumed by Australian households. The graph shows that while all indexes follow a similar path over the early part of the 1990s they diverge markedly after 1995-96. Over the whole period, prices for consumption expenditure rose by about 25%, while PBS pharmaceutical prices fell by 5% when measured at the brand and item level and rose by 2% when measured at the molecule level.

As noted earlier, direct indexes and the chained indexes calculated from them, necessarily compare a common set of products, i.e. they omit products that disappear from the market and new products that enter the market between periods t-1 and t.

The effect of omitting these disappearing and new products is set out in Table B7 in Appendix B. The impact is minor for disappearing products but is significant for new products, particularly in the years 1996-97 and 2000-01. It is more pronounced at the brand level, while at the item and molecule level the effects are fairly similar.[12]

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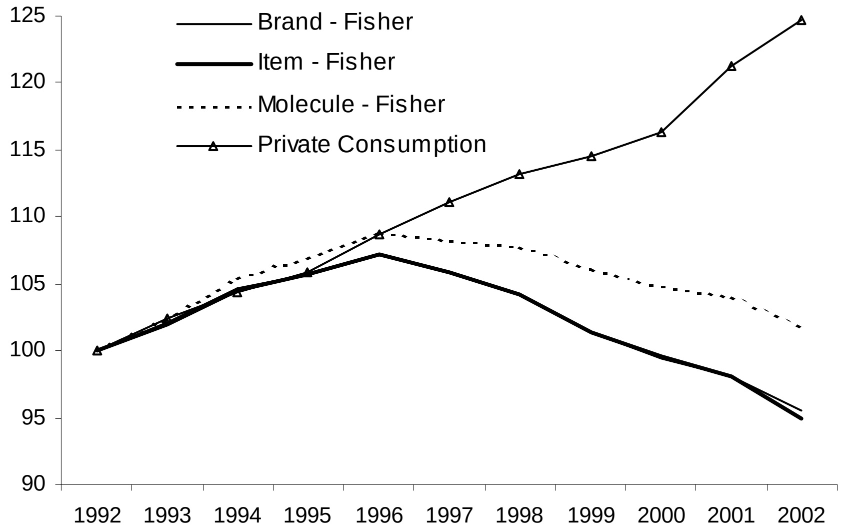
[12] Supplier codes change from time to time as companies are merged or acquired, or as agency and other marketing arrangements change. This will lead to more observations being

Figure 1 **PBS Chained Price Indexes**



4.2 Quantity Indexes

Direct and chained quantity indexes were compiled in a similar way to that for price indexes, using the formulae set out in Appendix A. The results are reported in Tables B4 to B6 and shown graphically in Figures B4 to B6 in Appendix B.

As with the price indexes, the Laspeyres and Paasche quantity indexes form upper and lower bounds within which all the other quantity indexes travel, with the exception of the Tornqvist index. This latter index behaves poorly at the brand level and is higher than the other indexes at both item and molecule level. It also diverges over time from the other indexes at the molecule level.

With the exception of the Tornqvist index, the quantity indexes produce very similar results, indicating a growth in demand for drugs within the PBS of about 190% over the period 1991-92 to 2001-02.

The unexpected results for the Tornqvist index are most likely due to the way this index weights the quantity relatives. Because quantities can change greatly from one period to another (for instance when a drug enters or leaves the market), quantity relatives will be much larger than price relatives because prices vary much less from period to period. The Tornqvist index seems to give more weight to extreme quantity relatives than does the Vartia index although they have similar formulae.

4.3 Indexes for Therapeutic Categories

The Anatomical Therapeutic Classification is used to classify drugs according to the systems they act upon in the body when targeting the disease for which they have been developed. At its broadest level the ATC has 14 major groups. However drug use and expenditure is concentrated in only a few of these categories. Table 1 shows

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omitted at the brand level than at the item level. Similarly new items for existing molecules can be added or deleted, meaning that items are more likely than molecules to be omitted.

that drugs in the following three categories accounted for 63% of total PBS expenditure in 2001-02,

- Alimentary tract and metabolism
- Cardiovascular system, and
- Nervous system

Table 1 PBS Expenditure Classified by ATC, 2001-02

Code	ATC Description	% of Cost in 2001-02
A	Alimentary tract and metabolism	13.7
B	Blood and blood forming organs	2.2
C	Cardiovascular system	31.1
D	Dermatologicals	1.6
G	Genito urinary system and sex hormones	3.2
H	Systemic hormonal preparations, excl. sex hormones	0.6
J	General antiinfectives for systemic use	5.5
L	Antineoplastic and immunomodulating agents	6.3
M	Musculo-skeletal system	6.7
N	Nervous system	18.2
P	Antiparasitic products, insecticides and repellents	0.2
R	Respiratory system	7.5
S	Sensory organs	2.1
V	Various	0.9

Chained price indexes calculated for each ATC major group display similar features to those reported in Section 4.1, with the symmetric indexes traveling within a fairly tight band defined by the Laspeyres and Paasche indexes.

The Fisher price indexes for the three most important ATC groups are given in Figure B7 in Appendix B. Drugs for treating alimentary tract and metabolic conditions and cardiovascular system diseases had slightly declining prices until 1997-98 but fell more sharply after that year. Drugs for the nervous system rose steadily to 1995-96 then suffered a sharp reduction before plateauing over the past few years.

The next three most important group of drugs accounted collectively for 21.5% of expenditure in 2001-02 and their experience has been more mixed (Figure B8). The prices of antineoplastic and immunomodulating agents fell steadily over the period, while those for musculo-skeletal conditions rose consistently before crashing in 2001-02. Drugs for respiratory conditions rose strongly until 1996-97 before falling somewhat and then continuing unchanged.

The remaining categories showed either consistently rising prices or with generally rising prices and some variation during the period (Figures B9 and B10). All ended significantly higher in 2001-02 than in 1991-92.

The falling prices since 1995-96 shown in the overall price indexes therefore have been driven by price reductions in the three most expensive drug categories.

5. Conclusions

Price and quantity indexes calculated for drugs available under the PBS confirm that the strong growth in expenditure over the past decade has been driven by increasing demand for prescription pharmaceuticals. This has been offset to some extent by the application within the PBS of reference pricing which since 1995-96 has acted to reduce drug prices in absolute terms. This is in contrast to other consumer products for which prices have risen.

Reference pricing has concentrated on those drugs in the PBS – such as drugs for treating peptic ulcers, cardiovascular drugs, and antidepressants – which contribute most to overall expenditure. By contrast drugs accounting for small proportions of cost have had price increases. In recent years, generic copies of originator drugs have accounted for a growing proportion of overall expenditure,[13] and the presence of these competitors has given the PBS greater ability to reduce drug prices through reference pricing.

Because both price and quantity data is available, chained symmetric price indexes such as the Fisher, Walsh, Tornqvist and Vartia indexes should be used in preference to Laspeyres and Paasche indexes to describe price trends with the PBS. As all symmetric chained price indexes produce virtually identical results, the Fisher index is preferred as it is simpler to calculate.

Chained symmetric quantity indexes should also be used in describing quantity trends. However the Tornqvist index is not recommended because of its sensitivity to extreme quantity relatives. Again the Fisher index is preferred.

Indexes calculated at the brand and item level produce very similar results. Item indexes however sacrifice proportionately less of the data when omitting new or disappearing drugs and are therefore preferred over brand level indexes.

On the other hand, molecule level indexes aggregate quantities for dissimilar forms and strengths of drugs, which may be misleading. Indexes therefore should be calculated at the item level where this problem does not occur.

A limitation of this analysis is that, because a chained approach is used and this omits new and disappearing goods, combining the price index and the quantity index will not reflect exactly what is happening with expenditure. This means that a better understanding of what is happening to overall demand for PBS drugs might be obtained by deflating the total expenditure data using the preferred chained price index. Figure 2 shows that quantity estimated this way using the Fisher price index at the item level implies a higher growth in quantity than does the Fisher quantity index.

In recent comparisons of prices and quantities, increasing attention has turned to the use of hedonic regression analysis to address both the problem of changing quality of products included within index calculations and the problem of new and disappearing products.[14] Changing quality occurs in drugs listed on the PBS only through the introduction of new drugs which are given a separate item code. In theory the application of cost-benefit analysis to determining the initial price of a drug should incorporate quality changes, which means that this problem should be either minor or non-existent.

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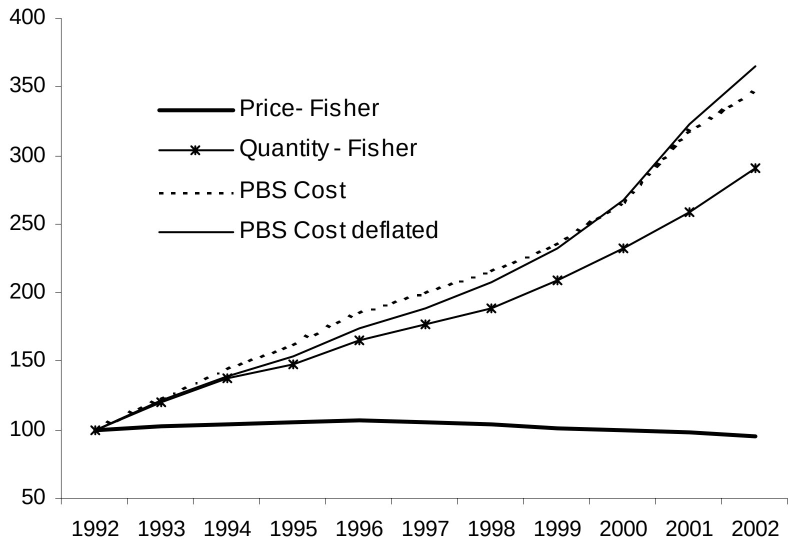
[13] Sweeny 2002b.
[14] See ILO 2003, Diewert 2001.

Hedonic regression used to address the problem of excluded products requires the construction of a large number of dummy variables which creates practical problems in its use. This will be addressed in further research.

Figure 2 **Components of PBS Cost**



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Appendix A Index Formulae

Price Indexes

Laspeyres $L_t = \dfrac{\sum_i p_{it}.q_{i0}}{\sum_i p_{i0}.q_{i0}}$

Paasche $P_t = \dfrac{\sum_i p_{it}.q_{it}}{\sum_i p_{i0}.q_{it}}$

Fisher $F_t = \sqrt{L_t \cdot P_t}$

Walsh $W_t = \dfrac{\sum_i p_{it}.\sqrt{q_{it} \cdot q_{i0}}}{\sum_i p_{i0}.\sqrt{q_{it} \cdot q_{i0}}}$

Tornqvist $T_t = \prod_i (p_{it} / p_{i0})^{\frac{1}{2}(w_{i0}+w_{it})}$, or $\ln T_t = \frac{1}{2}\sum_i [(w_{it} + w_{i0}).\ln(p_{it} / p_{i0})]$

Vartia $V_t = \prod_i (p_{it} / p_{i0})^{W_i}$, or $\ln V_t = \sum_i W_i \cdot \ln(p_{it} / p_{i0})]$

where

$$w_{it} = p_{it}.q_{it} / \sum_i p_{it}.q_{it}$$

$$W_i = \frac{(p_{it}.q_{it} - p_{i0}.q_{i0}) / (\ln(p_{it}.q_{it}) - \ln(p_{i0}.q_{i0}))}{(\sum_i p_{it}.q_{it} - \sum_i p_{i0}.q_{i0}) / (\ln(\sum_i p_{it}.q_{it}) - \ln(\sum_i p_{i0}.q_{i0}))}$$

Quantity Indexes

Laspeyres $L_t = \dfrac{\sum_i q_{it}.p_{i0}}{\sum_i q_{i0}.p_{i0}}$

Paasche $P_t = \dfrac{\sum_i q_{it}.p_{it}}{\sum_i q_{i0}.p_{it}}$

Fisher $F_t = \sqrt{L_t \cdot P_t}$

Walsh $W_t = \dfrac{\sum_i q_{it}.\sqrt{p_{it} \cdot p_{i0}}}{\sum_i q_{i0}.\sqrt{p_{it} \cdot p_{i0}}}$

Tornqvist $T_t = \prod_i (q_{it} / q_{i0})^{\frac{1}{2}(w_{i0}+w_{it})}$, or $\ln T_t = \frac{1}{2}\sum_i [(w_{it} + w_{i0}).\ln(q_{it} / q_{i0})]$

Vartia $V_t = \prod_i (q_{it} / q_{i0})^{W_i}$, or $\ln V_t = \sum_i W_i \cdot \ln(q_{it} / q_{i0})]$

Appendix B

Price and Quantity Indexes Tables and Graphs

Table B1 Chained Price Indexes – Brand Level

	Laspeyres	Paasche	Fisher	Tornqvist	Vartia	Walsh
1992	100.0	100.0	100.0	100.0	100.0	100.0
1993	102.4	101.8	102.1	102.1	102.0	102.1
1994	105.1	104.2	104.6	104.6	104.5	104.7
1995	106.2	105.2	105.7	105.7	105.6	105.8
1996	107.9	106.5	107.2	107.2	107.0	107.2
1997	106.7	104.9	105.8	105.8	105.8	105.9
1998	105.2	103.2	104.2	104.2	104.3	104.4
1999	102.1	100.6	101.3	101.3	101.5	101.5
2000	100.2	98.8	99.5	99.5	99.7	99.6
2001	98.6	97.5	98.1	98.0	98.4	98.3
2002	96.8	94.3	95.5	95.6	96.0	95.8

Table B2 Chained Price Indexes – Item Level

	Laspeyres	Paasche	Fisher	Tornqvist	Vartia	Walsh
1992	100.0	100.0	100.0	100.0	100.0	100.0
1993	102.2	101.8	102.0	101.8	102.0	102.0
1994	104.9	104.2	104.5	104.3	104.5	104.6
1995	106.1	105.2	105.6	105.5	105.6	105.7
1996	107.9	106.5	107.2	107.0	107.1	107.2
1997	106.7	104.9	105.8	105.7	105.8	105.9
1998	105.3	103.2	104.3	104.1	104.3	104.4
1999	102.3	100.6	101.4	101.3	101.5	101.4
2000	100.2	98.8	99.5	99.4	99.6	99.6
2001	98.6	97.4	98.0	97.9	98.2	98.1
2002	95.7	94.1	94.9	94.7	95.1	94.9

Table B3 Chained Price Indexes – Molecule Level

	Laspeyres	Paasche	Fisher	Tornqvist	Vartia	Walsh
1992	100.0	100.0	100.0	100.0	100.0	100.0
1993	102.5	102.1	102.3	102.3	102.3	102.3
1994	105.7	105.0	105.4	105.4	105.3	105.4
1995	107.3	106.4	106.9	106.9	106.8	106.9
1996	109.4	108.1	108.8	108.8	108.7	108.8
1997	109.2	107.4	108.3	108.3	108.3	108.3
1998	109.2	106.6	107.9	108.0	107.9	108.0
1999	107.3	105.0	106.1	106.2	106.2	106.2
2000	106.1	103.6	104.8	104.9	104.9	104.9
2001	105.5	102.8	104.1	104.2	104.2	104.2
2002	103.5	100.3	101.9	102.0	102.0	101.9

Table B4 Chained Quantity Indexes – Brand Level

	Laspeyres	Paasche	Fisher	Tornqvist	Vartia	Walsh
1992	100.0	100.0	100.0	100.0	100.0	100.0
1993	121.5	120.7	121.1	99.4	121.2	121.1
1994	138.4	137.2	137.8	112.8	137.9	137.8
1995	147.5	146.0	146.8	120.6	146.9	146.8
1996	164.9	162.7	163.8	129.3	164.0	163.8
1997	166.4	163.6	165.0	125.6	165.0	165.0
1998	174.5	171.2	172.9	108.3	172.6	172.8
1999	189.5	186.7	188.1	121.0	187.8	188.1
2000	208.2	205.3	206.8	114.6	206.3	206.8
2001	221.4	218.8	220.1	109.2	219.4	220.2
2002	241.4	235.0	238.2	98.5	236.9	238.1

Table B5 Chained Quantity Indexes – Item Level

	Laspeyres	Paasche	Fisher	Tornqvist	Vartia	Walsh
1992	100.0	100.0	100.0	100.0	100.0	100.0
1993	120.6	120.1	120.4	123.8	120.4	120.4
1994	137.6	136.6	137.1	141.8	137.1	137.1
1995	148.9	147.5	148.2	153.7	148.2	148.2
1996	166.9	164.8	165.8	172.5	165.9	165.9
1997	179.1	176.0	177.6	179.3	177.6	177.5
1998	189.8	186.1	188.0	189.0	187.9	187.9
1999	210.7	207.2	209.0	219.2	208.9	208.9
2000	233.9	230.7	232.3	237.0	232.1	232.3
2001	260.1	256.9	258.5	262.7	258.1	258.5
2002	293.1	288.1	290.6	298.6	290.0	290.5

Table B6 Chained Quantity Indexes – Molecule Level

	Laspeyres	Paasche	Fisher	Tornqvist	Vartia	Walsh
1992	100.0	100.0	100.0	100.0	100.0	100.0
1993	120.6	120.0	120.3	125.3	120.3	120.3
1994	137.1	136.2	136.6	143.7	136.7	136.6
1995	148.8	147.6	148.2	156.4	148.3	148.2
1996	167.1	165.2	166.2	176.1	166.3	166.2
1997	178.1	175.1	176.6	186.8	176.7	176.6
1998	190.3	185.8	188.0	198.2	187.9	188.0
1999	209.8	205.3	207.6	224.1	207.5	207.4
2000	238.2	232.5	235.3	253.9	235.2	235.2
2001	263.9	257.1	260.5	285.4	260.4	260.4
2002	295.9	286.6	291.2	322.2	290.9	291.0

Table B7 Effect of Omitting Observations for New and Dropped Drugs
$m

	Brand		Item		Molecule		Total
	Dropped	New	Dropped	New	Dropped	New	
1992	16.0		0.7		0.1		1,442.2
1993	0.1	15.7	0.1	9.7	0.0	4.7	1,779.4
1994	1.5	23.1	0.9	19.7	0.2	15.3	2,097.0
1995	3.6	86.5	0.8	52.4	0.1	34.9	2,341.9
1996	8.2	39.5	4.7	27.3	2.5	13.4	2,685.5
1997	8.4	217.0	1.9	44.7	0.1	39.2	2,878.5
1998	3.6	151.2	1.6	112.3	0.9	59.7	3,112.3
1999	3.7	106.9	1.0	32.8	0.3	17.8	3,397.0
2000	9.0	176.9	1.6	134.7	0.1	34.9	3,839.0
2001	15.2	545.0	1.3	358.5	0.4	343.8	4,564.7
2002		207.7		37.5		12.3	5,003.3

as % of Total Expenditure

	Brand		Item		Molecule		Total
	Dropped	New	Dropped	New	Dropped	New	
1992	1.1		0.0		0.0		100.0
1993	0.0	0.9	0.0	0.5	0.0	0.3	100.0
1994	0.1	1.1	0.0	0.9	0.0	0.7	100.0
1995	0.2	3.7	0.0	2.2	0.0	1.5	100.0
1996	0.3	1.5	0.2	1.0	0.1	0.5	100.0
1997	0.3	7.5	0.1	1.6	0.0	1.4	100.0
1998	0.1	4.9	0.1	3.6	0.0	1.9	100.0
1999	0.1	3.1	0.0	1.0	0.0	0.5	100.0
2000	0.2	4.6	0.0	3.5	0.0	0.9	100.0
2001	0.3	11.9	0.0	7.9	0.0	7.5	100.0
2002		4.2		0.7		0.2	100.0

Figure B1 Chained Price Indexes – Brand Level

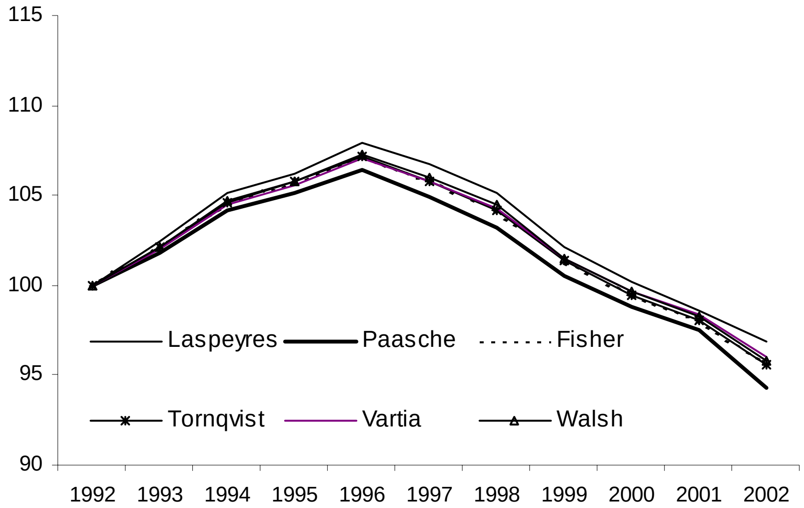

Figure B2 Chained Price Indexes – Item Level

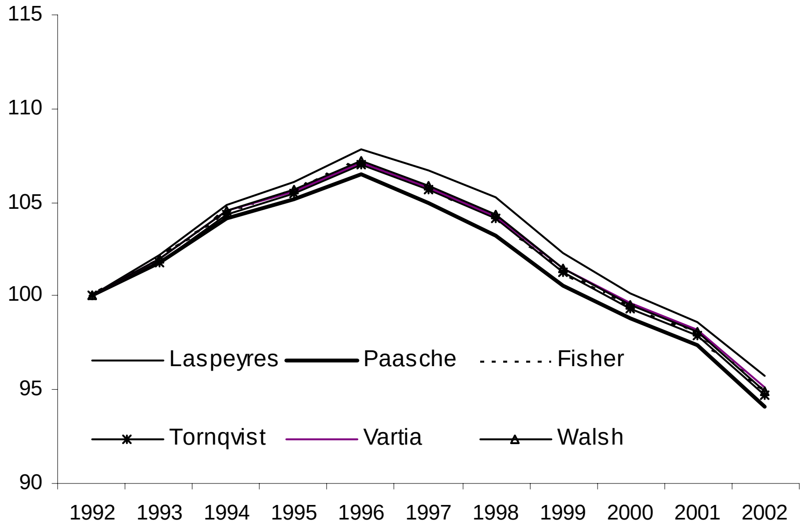

Figure B3 Chained Price Indexes – Molecule Level

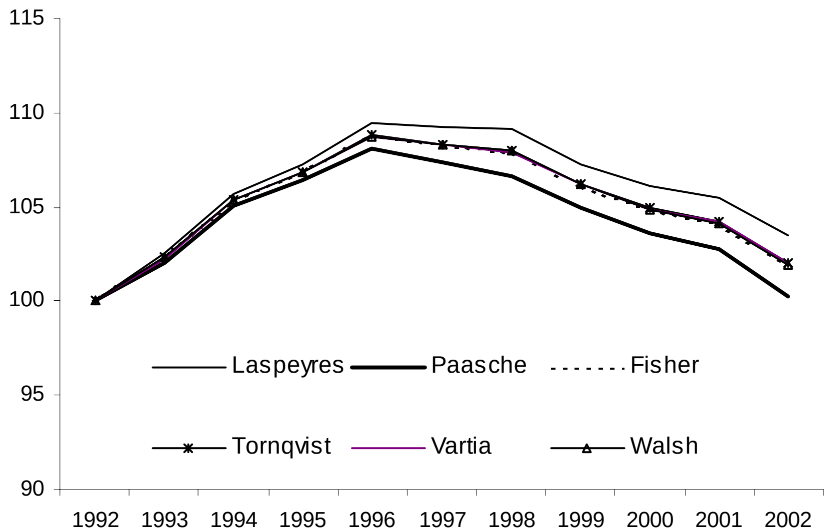

Figure B4 Chained Quantity Indexes – Brand Level

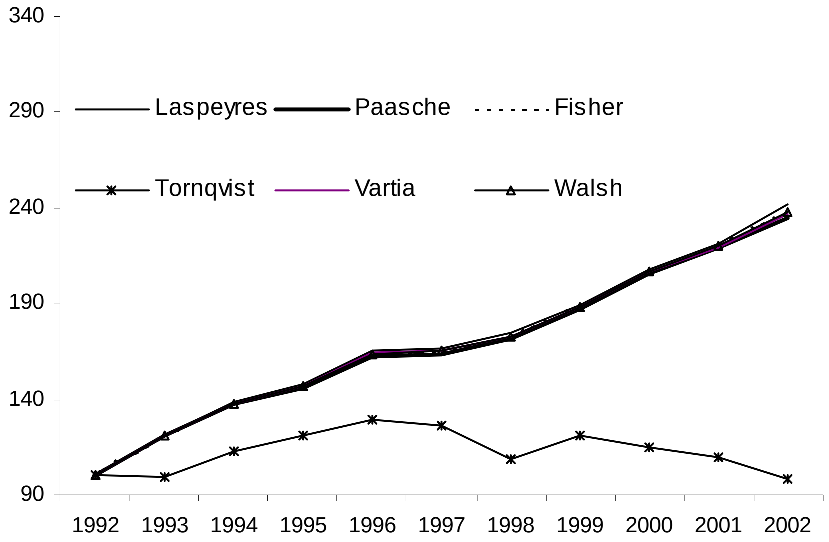

Figure B5 Chained Quantity Indexes – Item Level

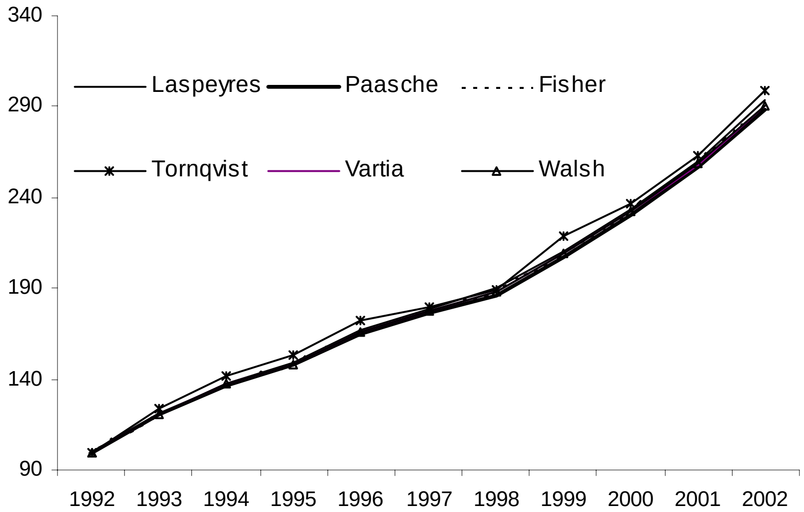

Figure B6 Chained Quantity Indexes – Molecule Level

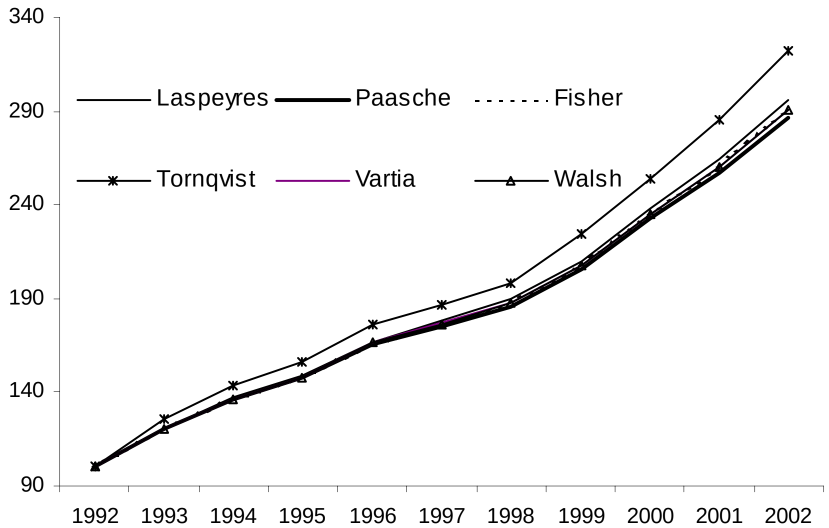

Figure B7 **Chained Price Indexes – ATC Groups A, C, N**

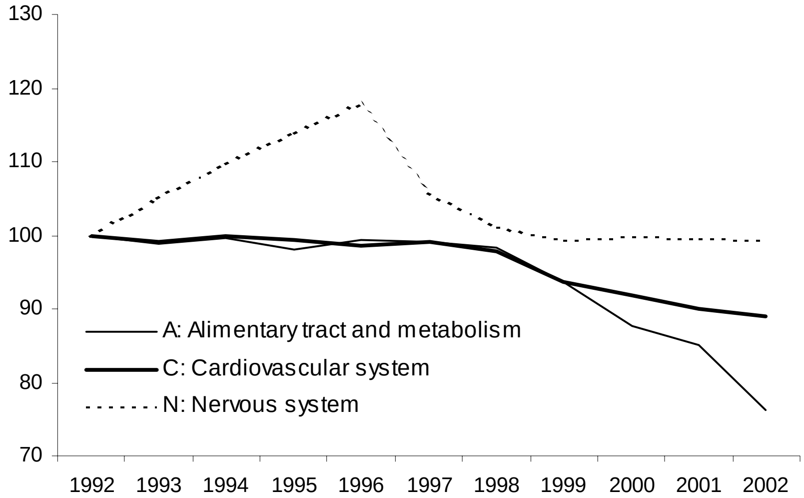

Figure B8 **Chained Price Indexes – ATC Groups L, M, R**

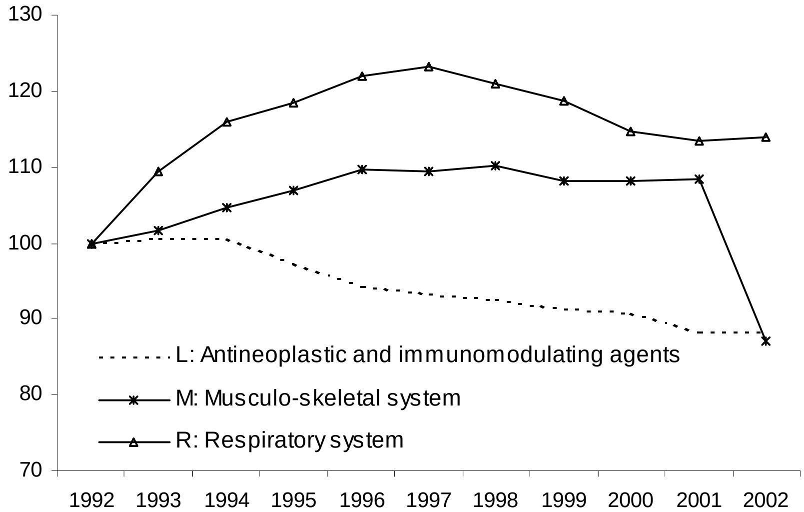

Figure B9 **Chained Price Indexes – ATC Groups B, D, G**

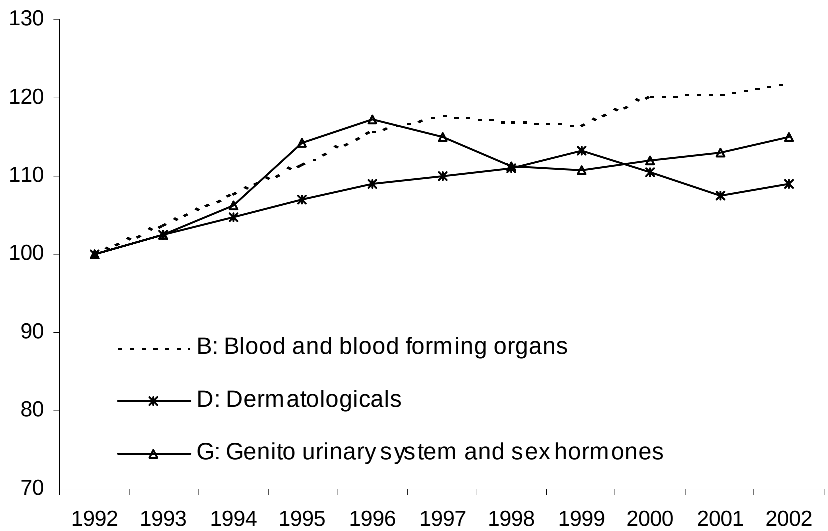

Figure B10 Chained Price Indexes – ATC Groups H, J, P, S