Chain Volume Measures in the New Zealand National Accounts

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Te Tari Tatau

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Preface

Statistics New Zealand currently operates a programme of ongoing quality improvements for constant price gross domestic product measures. These improvements include reviewing methodology and data sources, development of new series and rebasing.

The New Zealand System of National Accounts is currently based on the 1968 international standard, but a programme to implement the revisions to the standard, published in a *System of National Accounts 1993* (SNA93) is now under way.

An important recommendation in SNA93 is that annually-reweighted chain volume measures should be compiled to aid the analysis of economic statistics. SNA93 argues that chain volume measures provide better indicators of volume growth than base-weighted constant price estimates for most economic statistics relating to production and expenditure.

The series contained in this report comprise part of the National Accounts development work in the area of improving constant price estimates, in line with the SNA93 proposals. The next planned project will be to develop annual (and perhaps quarterly) constant price series balanced in an input output framework.

Section 12 of this report contains the experimental chainlinked indexes of the expenditure aggregates. Note that these statistics are not official. They are experimental series. They have been released to report on work to date and to invite comments from users about the concepts and methods employed in their derivation.

The chainlinked indexes will remain experimental until a final decision has been made by Statistics New Zealand whether to produce them on an ongoing basis, and replace the existing base-weighted constant price series.

The development of these series has been undertaken by the National Accounts Division with assistance from the Analytical Support Division. I would like to express my thanks to those involved, especially Michael Oliver and Michael Andrews. Statistics New Zealand also wishes to acknowledge the use of sections of a report published by the Australian Bureau of Statistics, “Introduction of Chain Volume Measures in the Australian National Accounts”.

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Acknowledgement

This report was prepared by the National Accounts Division and published by the Publishing and Community Information Division of Statistics New Zealand.

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Economic information

This report contains just a fraction of the total information available on the New Zealand System of National Accounts.

Hot Off The Press releases provide the latest summary statistics immediately the data is cleared for release. You can receive this information by post, facsimile or electronic mail.

Just contact Information and Consultancy Services to find out exactly what is available.

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Standards

■ Percentage changes

Percentage movements are, in a number of cases, calculated using data of greater precision than published. This could result in slight variations.

■ Rounding procedures

On occasion, figures are rounded to the nearest thousand or some other convenient unit. This may result in a total disagreeing slightly with the total of the individual items as shown in tables. Where figures are rounded the unit is in general expressed in words below the table headings, but where space does not allow this the unit may be shown as (000) for thousands, etc.

■ Changes of base

Where consecutive figures have been compiled on different bases and are not strictly comparable, a footnote is added indicating the nature of the difference.

■ Values

All values are shown in New Zealand currency, except where otherwise stated.

■ Source

All data is compiled by Statistics New Zealand, except where otherwise stated.

■ Symbols

The interpretation of the symbols used throughout this report is as follows:

-	nil or zero
—	amount too small to be expressed
..	figures not available
...	not applicable
R	revised
P	provisional
E	early estimate
C	confidential

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Contents

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1. Summary

At present Statistics New Zealand updates the base year of the published constant price gross domestic product series (and the price "weights" used to combine components of aggregates) every 5 to 10 years. To this extent the existing constant price series are chainlinked, but with links many years apart. Statistical agencies in countries such as the United States and Australia now update these weights on an annual basis. These countries have found that doing this can provide more accurate measures of growth. Annual updating of weights or chainlinking is also a recommendation of the System of National Accounts 1993.

For these reasons Statistics New Zealand has formed chainlinked indexes for each currently published expenditure aggregate. Chainlinked indexes of the production-based constant price GDP series have not yet been compiled.

The chainlinked indexes published in this report offer in some cases small gains in accuracy over the existing measures. Section 9 of this report estimates that for total expenditure on gross domestic product the annual increase in accuracy from chainlinking is between -1 and +3 percentage points. Larger improvements in accuracy are apparent for imports and gross fixed capital formation series where chainlinking, respectively, improved accuracy by up to 16 and 19 percentage points annually.

There also exist disadvantages to chainlinking. Comparisons between non-adjacent periods become more difficult to interpret. Chainlinking also causes loss of additivity in the series - the chainlinked value for an aggregate will not equal the sum of the chainlinked values of its components. This could pose serious difficulties for some users.

This report contains a full set of annually linked series for Gross Domestic Expenditure (GDE) and its components. These chainlinked indexes are, however, experimental series and it is proposed they will be updated periodically.

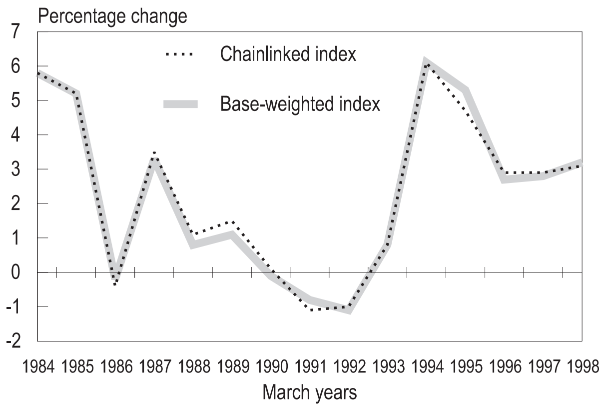
As experimental series, they have been released to report on work to date and to invite comments from users about the concepts and methods employed in their derivation.

The chainlinked indexes will remain experimental until a final decision has been made by Statistics New Zealand whether to produce them on an ongoing basis, and replace the existing constant price series.

Figure 1 compares the currently published base-weighted GDE in 1991 / 92 prices with a chainlinked Laspeyres GDE series, also in 1991 / 92 prices. Refer table F1, in section 10.

Figure 1

Comparison of growth rates for gross domestic expenditure



Statistics New Zealand also intends to examine chainlinked indexes for production series.

Following the development and release of chainlinked production based series, Statistics New Zealand will decide whether to continue chainlinking work based on the response of users.

Enquiries for further information or comments on the series contained in this report should be directed to:

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2. Introduction

Monitoring the current economic situation and forecasting key economic variables are fundamental aspects of modern economic management and analysis. They are activities which require a range of timely and accurate quarterly economic statistics central to which are those macroeconomic measures found in the national accounts, such as Gross Domestic Product (GDP) and its components. The focus of the New Zealand national accounts has primarily been the production of GDP series, of which the following are available quarterly:

- the production-based measure of GDP in constant prices - GDP(P)
- the expenditure-based measure of GDP in both current and constant prices - GDP(E). This measure is alternatively referred to as Gross Domestic Expenditure (GDE).

A brief history of the availability of these series is given in table A.

Table A	Base year	Start of series	First release date
Constant price series			
GDP (P)	1977/78	June 1977 quarter	November 1984
	1982/83	June 1977 quarter	October 1987
	1991/92	June 1977 quarter	June 1996
GDP (E)	1982/83	June 1982 quarter	June 1990
	1991/92	June 1982 quarter	June 1996
Current price series			
GDP (E)	not applicable	June 1982 quarter	July 1994 (experimental) February 1995 (official)

Tracking the economy over time

The compilation year after year of a system of national accounts generates a time series of the various economic statistics presented in the accounts. These statistics are made up of a multitude of transactions which, to be recorded, have to be expressed in terms of a common denominator, namely money. Comparisons over time using variable, current money values are not particularly meaningful, as the changes observed may only be a reflection of changing price levels rather than the volume of goods and services produced or consumed.

In order to overcome this type of problem a time series of national accounts can be expressed in the prices of one selected year of that series. Such a series is said to be expressed in constant prices or real terms. The aim of a system of constant price national accounts is to give numerical expression, free of price effects, to gross domestic product, its components or other national accounts series. This provides one of the principal indicators of the performance of the economy.

Expressing a statistic such as gross domestic product in constant prices involves revaluing a current price time series of goods and services in the prices of a chosen base year.

The series published in this report are expressed in constant 1991/92 dollars to maintain consistency with the official constant price series. Should annual chainlinking replace the base-weighted constant price series in the future the expression base would probably be the last complete financial year. This would require an update of the reference year with each March quarter release. Such updates would cause revisions to the dollar values of the indexes for their entire history (without altering any growth rate). This approach has the advantage of minimising the loss in additivity in the most recent periods.

Outline of this report

The outline of this report is as follows.

Sections 3 to 7 discuss chainlinked indexes and their theoretical advantages over other index formulations. These sections are reproduced from a report published by the Australian Bureau of Statistics on the recent release of their chainlinked GDP series, "Introduction of Chain Volume Measures in the Australian National Accounts" (Australian Bureau of Statistics 1998 (Cat. No. 5248.0)). Adaptations have been made for the New Zealand situation where needed.

Section 8

- discusses the chainlinked indexes published in this report and explains how they were formed
- examines the effects of chainlinking on the growth rates of the main expenditure aggregates
- considers the extent of non-additivity in the chainlinked indexes.

Section 9 contains a summary of the results of this exercise.
Section 10 outlines possible chainlinking work for the future.

Tables of experimental chainlinked series in 1991/92 prices are appended in section 12.

3. What is a Volume Index and How is it Constructed?

One of the prime uses of the national accounts is to measure growth in the volume of production and expenditure on goods and services between any two periods of interest.

It is easiest to start with a single homogenous commodity such as apples. For example, if 50 apples are produced in period 1 and 60 in period 2 then, assuming no change in their quality, the volume index for apples is given simply by the ratio of the two quantities (usually described as a 'quantity relative'). Setting the value of the index in period 1 to 100 means the value of the index in period 2 is 120, ie a 20 percent increase in the volume of production.

When there are two or more commodities, it is necessary to introduce some kind of weighting scheme. For instance, when oranges are produced as well as apples, it does not make economic sense simply to add the number of oranges to the number of apples if an orange is not worth the same as an apple. One way to weight each orange or apple is by its market price. In general, market forces may be expected to ensure that the relative prices of apples and oranges reflect not only the relative costs of producing them but also the relative utilities which consumers attach to them. A simple way of constructing a volume index is to value the apples and oranges at their prices in one or other period, and divide the total value of their combined production in the second period by that in the first. The same prices must be used for both periods to ensure that the index reflects only changes in quantities produced. It can already be seen that there is more than one way of measuring the volume change depending on whether the prices of the first or the second period are chosen. In general, they will not give exactly the same answer.

Another way of calculating volume indexes is where the ratios of the quantities, or quantity relatives, are calculated for apples and oranges separately. One would expect a volume index to be some kind of average of these quantity relatives. It can be shown that the indexes described in the previous paragraph are equivalent to weighted averages of the quantity relatives which use the total values of apples and oranges in one or other period as weights.

There are many possible ways of averaging the quantity relatives for the two commodities. They could be averaged arithmetically, geometrically or in some other way. Moreover, the weights could relate to values in the first of the two periods, the second period, some sort of average of the two, or possibly to values in some quite different period. Obviously, the choice of functional form and weights affects the growth rate of the volume index. At this point, it is convenient to introduce a numerical example to illustrate the various possibilities.

Forming a Laspeyres volume index

The following three tables illustrate the construction of volume indexes using an arithmetic functional form with weights that relate to a single period. Table B1 presents the quantity, price per unit of quantity, and value (price *times* quantity) of production for three different commodities in years 1, 2 and 3.

Table B1

Quantities, Prices and Values of Goods and Services Produced in Years 1, 2 and 3

	Year 1			*Year 2*			*Year 3*		
	Quantity	*Price*	*Value*	*Quantity*	*Price*	*Value*	*Quantity*	*Price*	*Value*
	q_1	p_1	p_1q_1	q_2	p_2	p_2q_2	q_3	p_3	p_3q_3
Commodity									
A	10	8	80	15	6	90	18	4	72
B	15	12	180	15	14	210	16	15	240
C	20	5	100	25	6	150	25	6	150
Total			360			450			462

Table B2

Quantities, Prices, and Values at Year 1 Prices

	Year 1			*Year 2*	
	Quantity q_1	*Price* p_1	*Value* p_1q_1	*Quantity* q_2	*Value* p_1q_2
Commodity					
A	10	8	80	15	120
B	15	12	180	15	180
C	20	5	100	25	125
Total			360		425

It can be observed from the last column of table B1 that the total value of production in year 2 expressed in year 1 prices is 425. Dividing this value by the value in year 1 (ie 425 / 360) gives an index value of 1.1805 in year 2. If the value of the index in the reference year, which in this example is year 1, is equal to 100 then this gives an index number of 118.05 for year 2 (1.1805x100). In other words, a growth in volume of 18.1 percent occurred between the two periods.

The type of index illustrated in table B1, which values the quantities in both years at the prices of the first year, is known as a 'Laspeyres' volume index. It can be interpreted as measuring the percentage change in the total value of production holding prices constant at their year 1 levels. It is also equal to a weighted arithmetic average of the quantity relatives for each of the three commodities using the values produced in the first year as weights.

Forming a Paasche volume index

Using the same set of information from table B1, an alternative index can be derived by valuing the quantities produced in year 1 at the prices of year 2, see table B3.

From table B3 it can be observed that the value of production in year 1 expressed in year 2 prices is 390. Setting the value for year 1 equal to 100 gives an index number of 115.38 for year 2 [(450 / 390)x100]. In other words, a growth in volume of 15.4 percent occurred between the two periods.

Table B3

Quantities and Prices, and Values at Year 2 Prices

	Year 1		*Year 2*		
	Quantity q_1	*Value* p_2q_1	*Quantity* q_2	*Price* p_2	*Value* p_2q_2
Commodity					
A	10	60	15	6	90
B	15	210	15	14	210
C	20	120	25	6	150
Total		390			450

The type of index illustrated in table B3, which values the quantities in both years at the prices of the second year, is known as a 'Paasche' volume index. This index, like the Laspeyres, also measures the percentage change in the total value of production, but by holding prices constant at their year 2 levels, instead of year 1. It can be shown that it equals a weighted harmonic average of the quantity relatives for the three commodities using the values of the second year as weights,

ie $[(90 / 450)x(15 / 10)^{-1} + (210 / 450)x(15 / 15)^{-1} + (150 / 450)x(25 / 20)^{-1}]^{-1}$

Differences in growth between the Laspeyres and Paasche indexes

Which is the better measure of growth - the 18.1 percent as calculated by the Laspeyres index, or the 15.4 percent as measured by the Paasche index? There is no simple answer to this question. Obviously the difference between the two indexes stems from the difference between the two sets of prices used because there is no difference between the quantities. What matters is the extent to which the pattern of **relative** prices (ie the ratio of the price of one commodity to another) changes over time and not the general rate of inflation. If all prices were to increase at the same rate the two volume indices would be equal, but if some prices go up faster than others, and especially if some go down while others go up, the two volume indices will diverge. The more variation there is in the price changes, the more the volume indexes will diverge.

Big changes in relative prices do occur. For example, the oil shocks of the 1970s caused the relative price of oil to rise dramatically, followed by gradual declines over subsequent years. An even more striking example is provided by computers of which relative prices have fallen substantially over several decades. Today they are only a tiny fraction of the relative price twenty or thirty years ago. Big changes in the relative prices of major goods or services imply that the price weights used in Laspeyres and Paasche volume indices must be very different. Because, however, most changes in relative prices tend to be systematic and cumulative, the differences tend to be greater the further apart the two periods.

It is no accident that the Laspeyres index is greater than the Paasche in the example used here. In general, when economic agents are price takers they tend to react to an increase (*decrease*) in the **relative** price of a commodity by buying less (*more*) of it. They substitute commodities which have become relatively cheaper for commodities which have become dearer, known as the 'substitution effect'. Thus commodities for which relative prices have fallen tend to have faster growth, while those for which relative prices have risen tend to have slower growth. By using the later prices *after* the substitutions have occurred, the Paasche index tends to give less weight to fast growing commodities, and more weight to slow growing ones. It tends to register a smaller overall volume increase than the Laspeyres index. This result is observed time after time in practice, although exceptions do occur occasionally.

Not only does the Laspeyres formula tend to exceed the Paasche, but these indexes effectively put upper and lower limits on the range of possible measures because other index number formulae that have been proposed almost invariably yield results that lie between them. Despite the divergence between them, both indexes have clear economic interpretations and strong claims to be taken seriously. By using the prices of the first period, the Laspeyres index measures growth from the perspective of the market situation prevailing in that period. Similarly, the Paasche index measures growth from the perspective of the second period. The problem is that growth is different when viewed from these two different perspectives. Neither index is inherently superior or preferable to the other, so the basic question remains of whether to accept the Laspeyres or the Paasche or, alternatively, opt for some other index that lies between them. This is often described as the 'index number problem'.

4. Economic Indexes

The underlying problem is as much economic as statistical. Economic theory has defined a 'true' measure of volume change, or growth, in terms of movements between points on some utility or production function underlying the observed price and quantity data. It can be shown that the Laspeyres index provides an upper bound to a true economic index based on the first period while the Paasche provides a lower bound to a true index based on the second period, assuming the underlying production function has certain conventional properties. This takes the argument one stage further, because it implies that not only does the Laspeyres index tend to exceed the Paasche, but it also actually tends to overstate 'true' growth from an economic point of view, while the Paasche index tends to understate it.

This overstatement or understatement of growth is often referred to as 'substitution bias' because it results from the substitution effect described above. The magnitude of the 'bias' will depend on the magnitude of the changes in relative prices. These tend to become cumulatively larger with the passage of time so that substitution bias tends to increase as the two periods compared become further apart. (Substitution bias may affect price as well as volume indexes.)

If the form of the underlying utility or production function were known, it would be possible to work out which index number formula would measure economic growth correctly. The Fisher Ideal Index (Fisher, 1921, hereafter referred to as the Fisher index) is defined as the geometric average of the Laspeyres and Paasche indexes. One well-known result (see, for example, Diewert, 1976) is that the Fisher index measures growth in consumption correctly if the utility function can be represented by a homogeneous quadratic function. In practice, however, it is not possible to be sure about the form of the underlying function, therefore the true growth rate also remains uncertain. On the other hand, certain formulae can be counted on to provide close approximations to the true index under a wide range of circumstances. Such formulae, including the Fisher index, have been described as 'superlative' indexes (Diewert, 1976). Given that the Fisher index is the geometric average of the Laspeyres and Paasche, this suggests that in many cases the true index is likely to lie roughly midway between them, although this cannot be taken for granted since it is not possible to know exactly where the true index falls.

When there are only two periods, it may be concluded that a superlative index, such as Fisher, is likely to provide the best measure of growth from an economic point of view. Nevertheless, other considerations such as cost and timeliness may, in practice, affect the choice of index number. The Laspeyres index, which does not require weights for the later of the two periods, is less costly than the Fisher and can typically be published more quickly, at least for the most recent periods. These factors have to be weighed against the theoretical advantages of the Fisher. If the gap between the Laspeyres and Paasche indexes is not very wide anyway, the Fisher may not be worth the extra trouble and delay. As shown later, one of the advantages of chaining is that it may reduce the gap between Laspeyres and Paasche indexes considerably.

Indexes covering three or more periods

The situation becomes more complicated when three or more periods are involved, and especially when time series of index numbers covering a period of many years are needed. Users are interested in growth rates over different spans of time and expect these to be comparable and consistent.

To go back to the illustrative data given in table B1, the growth in volume between year 2 and year 3 could be calculated, as well as between years 1 and 2. The same kind of calculation, as done for years 1 and 2 above, could be repeated (see table B4). The Laspeyres volume index could be calculated for year 3 based on year 2 (ie using year 2 prices); similarly, the Paasche index could be calculated for year 3 on year 2 (ie using year 3 prices); and, finally, the Fisher index could be derived by taking the geometric average of the Laspeyres and Paasche indexes. The respective increases for each index are:

- Laspeyres 7.1 percent being [(482 / 450)x100=107.11]
- Paasche 6.2 percent being [(462 / 435)x100=106.21]
- Fisher 6.7 percent being [square root (107.11x106.21)=106.66].

Table B4

Quantities and Prices, and Values at Year 2 and Year 3 Prices of Goods and Services Produced in Year 2 and Year 3

	Year 2				*Year 3*			
	Quantity	*Price*	*Value*	*Value*	*Quantity*	*Price*	*Value*	*Value*
	q_2	p_2	p_2q_2	p_3q_2	q_3	p_3	p_3q_3	p_2q_3
Commodity								
A	15	6	90	60	18	4	72	108
B	15	14	210	225	16	15	240	224
C	25	6	150	150	25	6	150	150
Total			450	435			462	482

When there are three years, besides the growth between years 1 and 2 and between years 2 and 3, the cumulative growth between years 1 and 3 is also of interest. One possibility is to cumulate the growth rates between years 1 and 2 and between years 2 and 3 by multiplying the respective indexes together. For example, the Laspeyres volume index (as calculated earlier) for year 2 on year 1 is 118.05; and that for year 3 on year 2 (as calculated above) is 107.11. This suggests that the cumulative index at year 3 (where year 1 has been set at 100) should be 100(1.1805x1.0711) = 126.4. The cumulative growth between years 1 and 3 is 26.4 percent.

On the other hand, it is possible to simply calculate the Laspeyres index for year 3 on year 1 directly, ignoring year 2. All the necessary price and quantity data for years 1 and 3 are already given in table B1. The total value of year 3 quantities at the prices of year 1 is 461. Dividing this by 360, the value of year 1 quantities at year 1 prices, gives a Laspeyres index for year 3 on year 1 of 128.06. This is not equal to the product of the two Laspeyres indexes for year 2 on year 1 and for year 3 on year 2 just calculated above. The result, therefore, is two different measures of the growth between years 1 and 3, both based on Laspeyres volume indexes.

Direct, indirect and chain indexes

It is useful at this point to introduce a general distinction between **direct** and **indirect** indexes. A **direct** index is an index which compares two periods directly with each other *using only the prices and quantities in those two periods.* The two periods do not have to be consecutive, of course, or even close together. For example, the direct Laspeyres volume index for 1994/95 based on 1986/87 can be calculated by valuing the quantities in 1994/95 at their prices in 1986/87.

As an alternative to comparing two periods directly, they can be compared indirectly via one or more other periods. An **indirect** index may then be defined as an index which is deduced from two or more direct indexes involving at least one other period in addition to the two periods being compared. For example, suppose there are three periods (not necessarily consecutive) *i*, *k*, and *m*: an indirect index for period *m* on *k* may be calculated using period *i* as a link by dividing the direct index for *m* on *i* by that for *k* on *i*. The link period may, or may not, lie between the two periods being compared. In the numerical example above, the cumulative index of 126.44 for year 3 on year 1 is an indirect index because it is deduced from the direct indexes between years 1 and 2 and between years 2 and 3.

An indirect index may require more than one link. When an indirect index links through two or more consecutive periods, it is usually described as a **chain** index. For example, a chain index for period *m* on period *i* is given by the product of the four direct indexes for periods *m* on *i*, *i* on *k*, *k* on *j* and *j* on *i*.

An indirect index necessarily introduces the prices or quantities of some other period, or periods, into the calculation of the index between the two periods being compared. At first sight, this may appear to be a disadvantage, but the use of this additional information can actually be an advantage in many circumstances, as explained later.

Going back to the numerical example above, it was shown that the direct and indirect Laspeyres volume indexes for year 3 on year 1 were unequal. They can scarcely be expected to be equal when the indirect index utilises price and quantity information from period 2 that the direct index ignores. In general, when direct and indirect indexes are not equal, the **direct** indexes are said to be **intransitive**. Almost all indexes, including Laspeyres, Paasche and Fisher, turn out to be intransitive. This is a further problem to be taken into consideration.

In principle, indirect indexes might be avoided by presenting users with direct indexes calculated between every possible pair of years. When there are n years the total number of possible pairs is n(n-1)/2. This means, for example, that over a run of ten years, 45 direct indexes would have to be calculated. The costs of calculating so many indexes could be prohibitive. However, calculating all possible direct indexes does not solve the underlying problem because users are not just interested in comparisons between particular pairs of years taken *in isolation*. Users are interested in comparing rates of growth over different time spans and expect the growth rates to be numerically consistent. However, when they are not transitive, different direct indexes cannot be numerically consistent. Users would not accept, for example, that the cumulative growth from 1986/87 to 1991/92 and from 1991/92 to 1994/95 does not equal growth measured over the ten-year period from 1986/87 and 1994/95 as a whole. An approach of publishing all possible direct indexes is therefore not appropriate.

In these circumstances, the best solution is to impose numerical consistency on the published data by providing users with *only n-1 direct indexes,* the minimum number needed to connect all *n* years. *All* the remaining indexes are then derived *indirectly*. In practice, all statistical offices do this. There are, however, two fundamentally different ways of going about it. For the purposes of creating the series published in this report Statistics New Zealand has, in effect, switched from one to the other.

The first method is to select a base year and calculate the *n-1* direct indexes between all the other years and the fixed base year. This is the procedure followed by Statistics New Zealand and most other statistical offices up to now. For example, 1991/92 is the most recent Statistics New Zealand base year and the volume indexes for all years from 1986/87 up to the present are fixed-weighted volume indexes that use the average prices of 1991/92. This implies that the indexes between *every pair of years which do not include the base year 1991/92* must be **indirect** indexes, including all the year-to-year indexes (except those including the base year).

The alternative method is to calculate the *n-1* direct indexes connecting successive pairs of years and to derive all remaining indexes indirectly. This is the solution that Statistics New Zealand has adopted to form the series in this report. It follows that all indexes except the *n-1* year-to-year indexes must be indirect indexes. An indirect index between two years that are several years apart has to be a chain index, as two or more links are needed.

In principle, the question of whether to calculate fixed-weighted volume indexes (or constant price series), or to calculate annual chain volume indexes is equivalent to asking which set of direct indexes is to be preferred: the *n-1* direct indexes on the same base year or the *n-1* direct indexes connecting successive pairs of years? In order to answer the question, the properties and behaviour of fixed-weighted and chain indexes need to be examined more closely. Fixed-weighted indexes will be considered first.

5. Fixed-weighted Indexes

When the quantities in a series of years are all valued at the constant prices of the first year, the movements in the resulting time series are identical with those of a sequence of fixed-weighted Laspeyres volume indexes each based on the first year. As explained above, however, the derived volume indexes between any pair of years *which do not include the base year* must be **indirect** indexes. They are not themselves Laspeyres indexes. For example, if year 1 is chosen as the base year for the data in table B1, the volume index for year 3 on year 2 calculated at the prices of year 1 is (461/425)x100=108.47. This increase of 8.5 percent between year 2 and year 3 may be compared with increases of 7.1 percent and 6.2 percent for the Laspeyres and Paasche indexes for year 3 based on year 2.

The base year does not have to be the first year and it is often placed somewhere in the middle of the sequence. For example, 1991/92 is currently used by Statistics New Zealand as the base year for all years back to 1986/87 as well as for later years. The volume indexes for all the years preceding the base year, ie for the years from 1986/87 to 1991/92, must be Paasche type, because they use the prices of the later of the two years being compared. Conversely, from 1991/92 onwards the indexes must be Laspeyres.

A series of fixed-weighted volume indexes can be converted into time series of dollar values at constant prices simply by multiplying the volume indexes by the current price dollar values in the base year. This is precisely the form of the Statistics New Zealand base-weighted constant price estimates from 1986/87 onwards. The resulting series at the constant prices of 1991/92 are equivalent to a run of Paasche type indexes followed by a run of Laspeyres type indexes.

As explained, economic theory suggests that the Laspeyres index tends to overstate the true rate of growth while the Paasche understates it. Thus, the fixed-weighted volume measures calculated by Statistics New Zealand will tend to understate growth between 1986/87 and 1991/92 and overstate it after 1991/92. The extent to which growth may be understated or overstated by fixed-weighted volume indexes depends on the rate at which patterns of relative prices are changing over time. Over a short sequence of years, the understatement or overstatement may sometimes be so small that it is trivial and difficult to detect, but in other situations it may be serious. If the under or overstatements are non-trivial then the resulting distortion in growth rates has to be a matter of concern to economic analysts and policy makers.

A similar concern was voiced about official fixed-weighted volume measures based on 1987 calculated for the United States. The US Bureau of Economic Analysis estimated that GDP volume growth since the recession trough in 1991 was overstated on average by 5 percentage points per year, whereas for the five economic expansions between 1960 and 1990, GDP volume growth was understated on average by 5 percentage points a year (Landefeld and Parker, 1995). In 1995, the US Bureau of Economic Analysis abandoned fixed-weighted volume measures in favour of annually-reweighted chain Fisher volume measures.

The extent to which growth may be understated or overstated by fixed-weighted volume indexes depends on the rate at which patterns of relative prices are changing over time. Over a short sequence of years, the understatement or overstatement may sometimes be so small that it is trivial and difficult to detect, but in other situations it may be serious.

Further problems arise when the base year for a series of fixed-weighted indexes is changed. If the original base year is the first year, the indexes are all Laspeyres type, but if the base year is moved to the last year they become Paasche type and smaller volume increases will be recorded. In general, moving the base year forward in time will tend to reduce the growth rates previously recorded so that they have to be revised downwards. History is rewritten. This is illustrated in table C which compares growth in total gross domestic expenditure as measured by the currently published base-weighted series in 1991/92 prices and the previously published base-weighted series in 1982/83 prices.[1] The size of the downward revisions ranges between 2 and 20 percentage points.

[1] Note that changes to methodology and revisions to component series also contribute to differences in growth rates in this table.

Table C

Year ended March	Published base-weighted series in 1982/83 prices: percent growth from previous year (percent)	Published base-weighted series in 1991/92 prices: percent growth from previous year (percent)	Difference (percentage points)
1988	2.8	0.8	-20
1989	1.6	1.1	-5
1990	1.1	-0.1	-12
1991	-0.9	-0.8	1
1992	-0.9	-1.1	-2
1993	0.6	0.8	2

Statistical offices that compile fixed-weighted volume indexes are obliged to update their base years periodically, otherwise the price weights become obsolete and irrelevant. The slowing down of previously recorded growth rates attributable to updating the base year can sometimes be so pronounced, especially for fast-growing economies, that it is difficult for users to understand and may not be readily accepted by governments. The longer updating the base year is postponed, the greater the revisions are liable to be.

Fixed-weighted volume indexes and their associated constant price value series are well established and widely used in analysing New Zealand's national accounts. They are also additive, which means that the constant price aggregates can be decomposed, or components aggregated, as necessary, without discrepancies being created between the components and the aggregates. These are important advantages.

On the other hand, fixed-weighted indexes may not provide the best measures of growth, especially for long runs of years. When the first year is chosen as the base year, growth tends to be overstated, especially for the later years which are furthest away from the base year. When the base year is placed in the middle, growth tends to be understated for the earliest years and overstated for the latest years. The growth rates are dependent on the somewhat arbitrary choice of base year. Moving the base year to a later year tends to reduce growth rates, so that the periodic updating of the base year can cause significant downward revisions to growth rates.

The year-to-year movements of a fixed-weighted index are indirect indexes which use the base year as the link between direct indexes. For example, the current Statistics New Zealand practice is to measure growth from 1993/94 to 1994/95 using 1991/92 as the link between direct indexes from 1991/92 to 1993/94 and 1991/92 to 1994/95, even though it is easier to compare 1993/94 and 1994/95 directly than through the base year. An indirect measure of this kind cannot provide the best measure of year-to-year growth and becomes less and less acceptable the further away from the base year.

6. Chain Indexes

In order to understand the advantages and disadvantages of chaining, it is necessary to establish how the resulting indirect index between two years that are far apart may be expected to behave in comparison with the corresponding direct index between the same two years. Chain indexes are inevitably path dependent, that is, a chain index does not depend simply on how much the prices and quantities in the two years differ from each other, but also on how the prices and quantities move in the intervening years.

It is particularly important to establish how chaining affects the relationship between Laspeyres and Paasche indexes, a chain Laspeyres (Paasche) volume index being defined as one in which each direct index between two consecutive periods uses the prices of the first (second) period as weights.

Suppose that most relative prices and quantities tend to change monotonically, that is, to have persistent tendencies either to rise or to fall without fluctuating. For a relative price or relative quantity to fall monotonically, it does not need to fall at a steady rate, but it should either fall, or remain unchanged, from one period to the next. Assuming that relative prices and quantities change monotonically and that Laspeyres indexes are greater than Paasche indexes, a chain Laspeyres volume index will increase less than the direct Laspeyres while the chain Paasche will increase more than the direct Paasche. Chaining reduces the Laspeyres-Paasche gap, ie the difference between average rates of growth derived from the Laspeyres and Paasche indexes will be reduced.

In practice, not every relative price and quantity can be expected to change monotonically throughout, but provided most prices and quantities behave this way most of the time, chaining will still reduce the gap. When the data is annual, most of the average annual prices and total quantities may be expected to move monotonically.

Chaining seems desirable whenever it reduces the Laspeyres-Paasche gap in this way because the measurement of economic growth (or inflation) becomes less sensitive to the choice of index number formula. The index number problem itself is reduced. The underlying explanation is as follows. When relative prices and quantities tend to change monotonically, the pattern of relative prices in the first year is gradually transformed into that of the last year. The changes in relative prices between consecutive pairs of years are then obviously much smaller than the cumulative changes between the first and last years. The smaller the changes in the relative prices, the less sensitive the volume measures are to the choice of index number. (At the limit, if the relative prices were to remain the same between two years, the index number problem would disappear because the Laspeyres and Paasche volume indexes would coincide.) By calculating the *n-1* direct volume indexes between consecutive time periods the resulting Laspeyres-Paasche gaps are likely to be minimised, not merely for the direct indexes themselves, but also for all the indirect indexes derived from them. The Laspeyres-Paasche gaps for the resulting indirect (ie chain) indexes, whether the years are close or far apart, will tend to be less than the gaps for the corresponding direct or indirect indexes derived from a set of fixed-weighted indexes.

On the other hand, the situation may be quite different if relative prices do not change monotonically. When there are important fluctuations in relative prices and quantities, the chain Laspeyres may increase more, and the chain Paasche less, than the corresponding direct indexes, so that the Laspeyres-Paasche gap actually widens. This may happen with both *annual* and *sub-annual* data. For example, chaining quarterly or monthly data subject to regular seasonal fluctuations is liable to increase the gap (but not if the fluctuations are removed by seasonal adjustment).

Suppose, for purposes of argument, that an initial set of changes in relative prices is subsequently reversed so that the pattern of relative prices returns to what it was in the first period. Every relative price fluctuates. In this case, a direct volume index should be calculated between the first and last periods because the direct Laspeyres and Paasche volume indexes must be equal if the relative prices are the same in both periods. There is no index number problem. Chaining through the intervening periods produces unacceptable results because the changes in relative prices between consecutive periods are actually much greater, by assumption, than they are between the first and last periods.

Although price fluctuations do occur, most annual average prices tend to change monotonically. In practice, economies tend to evolve in such a way that changes in relative prices and quantities get cumulatively larger over time instead of reversing themselves. This also suggests that the set of goods and services on the market is continually changing over time. Just as the pattern of relative prices may move gradually further and further way from its initial state, the quantities may also do so, especially as new goods and services appear while older ones disappear. In this situation, it becomes increasingly difficult to calculate direct indexes over long periods of time as the overlap between the sets of goods and services available in both years gets progressively smaller.

Price changes can only be calculated for goods and services found in both years. As the overlap between the goods and services will usually be greatest in consecutive years, the direct volume and price indexes between them will be able to exploit virtually all the price and quantity information available in each year. On the other hand, direct indexes calculated between years much further apart may only be able to utilise a fraction of the information in each year. It may eventually become a practical impossibility to calculate satisfactory direct indexes between two years very far apart because they have so few goods and services in common.

Even when the 'same' goods or services are found in both years their quality may have changed. Improvements in quality are equivalent to increases in quantity, but they become increasingly difficult to measure as the quality changes get bigger. It is difficult enough to measure the improvement in the quality of computers from one year to the next, but trying to measure the improvement in the quality of computers in a direct comparison over ten or more years poses almost insurmountable problems. Changes in quality may become so great that the goods or services can no longer be treated as the same, so that direct comparisons of their prices and quantities with those in earlier periods have to be abandoned.

The problems caused by quality changes, new goods and disappearing goods are minimised by annual chaining because the sets of goods and services available in consecutive years have more in common than those in years further apart. Put another way, the amount of useable price and quantity information is maximised for direct indexes calculated between consecutive years. A direct index for two years far apart may have to ignore most of the prices and quantities in each year because there are no comparable prices and quantities in the other year. The resulting direct index would have poor coverage and limited economic significance.

Direct year-to-year volume indexes must, therefore, be more reliable than direct indexes between years further apart, whatever type of index is used. The greater reliability of year-to-year indexes considerably reinforces the case for chaining put forward earlier, even though it stems from the same basic phenomenon - namely the fact that relative prices and quantities in consecutive years are more similar than those in years further apart. The combination of greater reliability and a reduced Laspeyres-Paasche gap constitutes a powerful, and possibly decisive, argument in favour of annual chaining if the objective is to obtain the best possible measures of growth.

7. Choice of Index Number Formula

Although annual chaining reduces the index number problem it does not dispose of it completely. There remains the question of which index number formula to use in a chain index: Laspeyres, Paasche, Fisher, or perhaps some other index? When there are only two periods it has already been explained that, in principle, a superlative index, such as Fisher, is preferable to Laspeyres or Paasche because it is likely to provide a closer approximation to the underlying economic index. This suggests that each of the individual year-to-year direct indexes from which an annual chain index is constructed should also be superlative.[2]

Advantage of the Fisher index over Laspeyres

An important advantage of a chain Fisher index over a chain Laspeyres or Paasche index is that it is less sensitive to fluctuations in price and volume relativities because it satisfies the time reversal test. This means that, unlike a chain Laspeyres or Paasche index, a chain Fisher index is not liable to 'drift' outside the range spanned by direct Laspeyres and Paasche indexes when relative prices or relative volumes fluctuate. Chaining is not recommended for series that fluctuate, especially sub-annual data subject to seasonal fluctuations. If these series do have to be chained, however, Fisher is preferred to either Laspeyres or Paasche. An example of an aggregate with components whose price and volume relativities fluctuate is exports of goods, where fluctuations occur due to factors like volatility in exchange rates.

Advantages of Laspeyres over Fisher

Nevertheless, the theoretical advantages of Fisher indexes may not always be decisive. It is also necessary to take account of data availability, cost, timeliness, empirical evidence and other practical considerations.

A significant practical consideration stems from the annual linking of quarterly data. It is generally considered best to reweight volume and price indexes no more than annually for the following reasons. First, quarterly data is subject to greater volatility than annual data. That part of the short-term volatility that is seasonal can be removed by seasonal adjustment, but this requires seasonally adjusting all the elemental components of an index.

Quarterly chain Fisher-like indexes that are reweighted annually can only be compiled up to the year prior to the latest complete year and not beyond. This end point problem was faced by the US Bureau of Economic Analysis when it introduced such indexes in 1995. Its initial solution to the end point problem was to have Laspeyres indexes for the latest year or so. In 1997 it abandoned that solution and now compiles quarterly chain Fisher indexes that are reweighted quarterly for the latest periods.

The results of an empirical analysis comparing results obtained using different index formulae are presented and discussed in section 11.

To round off this discussion it may be useful to pull together the numerical results from the illustrative data given in table B1. The key results are the differences between the direct and the chain indexes for year 3 on year 1. These are shown in table D.

Table D

Comparison between Direct and Chain Volume Indexes

Percentage changes between year 1 and year 3			
Direct Laspeyres	28.1	Chain Laspeyres	26.4
Direct Fisher	24.0	Chain Fisher	24.5
Direct Paasche	20.0	Chain Paasche	22.8

The chain indexes have only one link in year 2. The difference between the direct Laspeyres and Paasche indexes is 81 percentage points. Chaining reduces the difference to 36. As this example is artificial, a few additional comments may be in order. The direct Laspeyres is greater than the direct Paasche because the substitution effect is built into the data. By making the relative price changes in the original data in table B1 more pronounced, and the negative correlation between the changes in relative prices and quantities stronger, the Laspeyres-Paasche gap would be increased further. Secondly, relative prices move monotonically so that chaining reduces the gap, as expected in these circumstances. If the prices in year 2 were to be fixed so that each price moved even more smoothly from year 1 to year 3, chaining would reduce the gap even more. Finally, it may be noted that there is no reason to prefer the chain Fisher to the direct Fisher in this particular example as the same three commodities are well represented in both years 1 and 3.

[2] The Fisher index is not the only superlative index formulation. Diewert (1995) explains that the actual choice between superlative indexes is relatively unimportant, however, because each tends to give similar results.

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8. Chainlinked Series Contained in this Report

Tables 1.1 to 6.6 in section 12 contain the experimental chainlinked indexes of the expenditure aggregates.

These series are not official statistics. They are experimental series. They have been released to report on work to date and to invite comment from users about the concepts and methods employed in their derivation. Statistics New Zealand has not decided whether to produce these series on an ongoing basis, nor whether they might replace the existing base-weighted constant price series. The seasonal adjustments are also provisional at present.

The chainlinked expenditure series are of Laspeyres formulation. This choice is based on the practical considerations discussed in the previous section. Statistical agencies in several other countries, including Australia, have also chosen the Laspeyres formulation for these reasons.

Compilation of the chainlinked series

The chainlinked series contained in this report were calculated from the same series used to form the current and constant price expenditure series. The basic steps in forming the chainlinked annual series are as follows:

1. The detailed working series in each year are valued in the prices of the previous year.
2. These values are summed to the level of aggregation of the published series to form the numerator of the movement for each year.
3. The numerator value for each year is divided by the previous year's current price value (also at the published level of aggregation). This gives a series of direct Laspeyres movements between each consecutive pair of years.
4. The movements are compounded to form an annually chainlinked index.
5. The index is scaled so that the value in 1991/92 is equal to the current price value of the series in that year. The result is an annually linked index expressed in the prices of 1991/92.

The annually chainlinked quarterly series are formed in a similar way to the annual series. Points to note are:

- Movements between consecutive quarters are formed using annual as opposed to quarterly prices for weights.
- Movements between consecutive quarters within the same March year are weighted using the annual prices of the previous March year.
- Movements between the last quarter in each March year and the first quarter in the following March year (ie March-June movements) are weighted using the annual prices of the earlier March year.

Chainlinked indexes for increase in stocks series are formed differently from other series. The fact that increase in stocks series take values that can be near to zero or negative, often means that movements cannot be calculated. Consider the case for example, when the current price value of the published series is zero in a year. In this case it is not possible to form the series of direct Laspeyres movements in step 3 above because this requires division by zero. These and other related problems mean that the standard approach to forming chainlinked series produces unsatisfactory results for increase in stocks series.

For these reasons some countries do not publish chainlinked indexes for increase in stocks series. Statistics New Zealand has adopted the approach of the Australian Bureau of Statistics.[3] This approach is to form chainlinked series of stock levels and take the difference between these to form an "increase in stocks" series.

It is important to note that increase in stocks is not treated in this way when chainlinking gross national expenditure and gross domestic expenditure. Step 3 above never requires division by zero for these series because the current price values of gross domestic expenditure and gross national expenditure are always positive. It is therefore possible to treat increase in stocks series in the same manner as other series when chainlinking these larger aggregates.

[3] The United States Bureau of Economic Analysis also uses this approach to forming chainlinked stocks series.

One further point to note concerns the method used to express the chainlinked increase in stocks series in the prices of 1991/92. The method used has been to reference the stock levels series before taking the differences. Effectively the index is scaled so that the value of the levels index in 1991/92 is equal to the current price value in this year. This approach causes a small difference between the chainlinked and current price increase in stocks values in the reference year. This difference causes a loss in additivity in the reference year between the values of aggregates which contain increase in stock components and the sum of the components. Series which contain increase in stocks components are total expenditure on gross domestic product, total gross national expenditure and total increase in stocks.

Seasonal adjustment

The X12-ARIMA seasonal adjustment package has been used to produce the seasonally adjusted chainlinked series. Seasonal adjustment aims to eliminate the impact of seasonal effects (such as the apple growing season which would affect exports) and calendar effects (such as Christmas) on time series. This makes the data for adjacent periods more comparable.

When seasonally adjusting the series which contribute to Gross Domestic Product, Statistics New Zealand uses a combination of indirect (component level) and direct (aggregate level) adjustment. Both methods are assessed for each series. In principle the method which best removes the seasonality is chosen, but if, however, there is very little difference between the two methods then the indirect approach is usually chosen. This is because direct adjustment results in a loss of additivity between the component series and the total.

The loss of additivity caused by direct seasonal adjustment poses less of a problem for chainlinked series because these series are not additive before adjustment.

All of the seasonally adjusted series contained in this report have been adjusted at the level of aggregation at which they are published.[4] The procedure used has been to individually adjust each series at the level of aggregation at which it is published. Increase in stocks series have been adjusted after taking the differences between the chainlinked levels.

Seasonally adjusted estimates towards the end of the series incorporate new data as it becomes available and can therefore change as more observations are added to the series. Revisions can be particularly large if an observation is treated as an outlier in one period but is found to be part of the underlying trend as further observations are added to the series. All seasonally adjusted estimates are subject to revision each quarter but normally only the last two or three estimates are likely to be substantially altered. The chainlinked index series are experimental and it is likely any changes to the data will cause sizeable revisions of the seasonally adjusted data.

Implicit price deflators derived from chainlinked series

Tables 7.1 to 7.3 in section 12 contain implicit price deflators calculated from the chainlinked indexes. These implicit price deflators are calculated by simply dividing the current price value of the series by the chainlinked value in each period.

These series take the form of a chainlinked Paasche price index. The indexes should measure growth in prices more accurately than the base-weighted implicit price deflators. The reason for this is that the volumes which form weights in the index are updated annually and are therefore more relevant than those of the base-weighted implicit price deflators. This reasoning is analogous to that used earlier to explain why a chainlinked volume index will often measure growth more accurately than a base-weighted index.

Impact of chaining on growth rates

Chainlinking the gross domestic product expenditure series has provided alternative estimates of growth. The size of the difference between growth rates in the base-weighted and chainlinked indexes depends on both the amount of variation in relative prices and the responsiveness of expenditure to that variation.

Tables F1 to F7 compare growth rates between the base-weighted and chainlinked indexes for the main expenditure aggregates.

For total expenditure on gross domestic product the differences in growth rates are less than 3 percentage points in most years.

Larger differences in growth rates occur for the gross fixed capital formation, total imports and total gross national expenditure series. These differences are largely a result of the importance of goods such as computers that have undergone rapid price and volume change.

Another feature of tables F1 to F7 is a tendency for the growth rate in the chainlinked index to exceed that of the base-weighted between 1987 and 1992, but be lower from 1992 onward. To some extent this is apparent for all aggregates in tables F1 to F7.

[4] This is called direct adjustment. It is also possible to perform seasonal adjustments at lower levels of aggregation (indirect adjustment). Statistics New Zealand uses a combination of direct and indirect adjustment for its official GDP series. If Statistics New Zealand decides to continue to publish chainlinked series, then the seasonal adjustments for some series may be reviewed.

As explained below these differences may suggest that chainlinking has improved the accuracy with which, in some cases, growth is measured.

In section 4 it was noted that the currently published base-weighted constant price series are of Paasche formulation from 1987-1992 and Laspeyres from 1992 onward. It was predicted that these indexes would underestimate growth between 1987 and 1992 and overestimate growth from 1992 on. The chainlinked indexes contained in this report are of Laspeyres formulation and can be expected to overestimate growth.

From the earlier sections, it will be recalled that the Fisher index is superlative and can therefore be considered unbiased. These properties make the Fisher index a useful benchmark for assessing the accuracy of other indexes. By subtracting the growth rate in the chainlinked Fisher from those of the base-weighted and chainlinked Laspeyres indexes, the possible size and direction of bias can be estimated.

Tables G1 to G7 compare the growth rates in the base-weighted and chainlinked Laspeyres indexes with those of the chain Fisher. Columns 5 and 6 give the difference in growth for the base-weighted and Laspeyres chainlinked indexes in comparison with the chainlinked Fisher index. These differences estimate the possible size and direction of bias in the indexes. Column 7 gives the estimated percentage point reduction in bias resulting from using a chainlinked Laspeyres index in preference to the base-weighted.

Tables G1 to G7 contain growth rates only from 1988 onward. The reason for this truncation is that the base-weighted indexes contain a link in 1987. This makes interpretation of differences in growth more difficult.

Table E, below, makes similar comparisons for each aggregate for growth over the periods 1987-1992 and 1992-1998.

An important point to note from table E is that the estimate of the bias in the base-weighted index is in most cases negative between 1987 and 1992, and positive from 1992 onward. Further, the estimates of bias in the chainlinked Laspeyres indexes are mainly near to zero or positive. Tables G1 to G7 show that this behaviour is also apparent for annual growth rates. These observations are consistent with the earlier predictions about the direction of potential bias.

This pattern is less apparent for the total exports series. The predictions about the direction of potential bias were based on the observation that ‘substitution effects’ tend to cause the relative volume of any

Differences in growth for chainlinked and base-weighted indexes

Table E

Series	Published Base-weighted Series Total Growth Over Period (percent)	Chain Laspeyres Index Total Growth Over Period (percent)	Chain Fisher Index Total Growth Over Period (percent)	Estimated percentage point bias in published base-weighted series	Estimated percentage point bias in chain Laspeyres index	Estimated percentage point reduction in bias from chainlinking
1987-1992						
Gross domestic expenditure	-0.2	0.5	0.3	-5	2	3
Gross national expenditure	-1.5	-0.6	-0.7	-8	1	7
Private final consumption expenditure	2.2	3.2	2.7	-5	5	0
Government final consumption expenditure	5.9	6.8	6.6	-7	2	5
Gross fixed capital formation	-17.0	-16.3	-16.5	-5	2	3
Total exports	22.6	23.4	22.3	3	11	-8
Total imports	17.7	20.8	19.7	-20	11	9
1992-1998						
Gross domestic expenditure	22.7	22.3	22.0	7	3	4
Gross national expenditure	30.1	27.6	27.7	24	-1	23
Private final consumption expenditure	22.8	22.8	22.9	- 1	-1	0
Government final consumption expenditure	12.8	12.6	12.8	0	-2	-2
Gross fixed capital formation	71.8	62.5	62.3	95	2	93
Total exports	30.9	29.8	28.9	20	9	11
Total imports	59.3	54.2	53.2	61	10	51

individual set of goods to fall in response to a rise in its relative price (and vice versa). This behaviour is less apparent for exports series for two reasons. Firstly, the correlation between relative prices and volumes of exports tends to be fairly weak for New Zealand. Secondly, the correlation is disguised by fluctuations in relative prices caused by factors other than volume changes.

New Zealand makes up only a small fraction of the total world supply for many of the goods it exports. This means that fairly large changes to the New Zealand supply of a particular exported good tends to have only very small effects on the price received for that good. Hence the negative correlation between relative prices and volumes is fairly small.

Transactions involving exports are often denominated in foreign currencies. This means that changes to exchange rates affect the relative prices received for New Zealand exports. Exchange rate fluctuations therefore cause changes to relative prices of exports which are unrelated to volume changes. These changes disguise the negative correlation between relative prices and volumes caused by substitution effects.

Over the period 1987-1992 it is estimated that there is a small positive bias in the base-weighted series for total exports. Given that the base-weighted series is of Paasche formulation a negative bias would normally be expected to be present. Underlying this prediction, however, is the expectation that as the relative price of a particular good rises, purchasers substitute away from that good. In the case of New Zealand exports this behaviour is less likely because New Zealand exports make up a fairly small proportion of the world supply of exported goods.

It appears that the chainlinked Laspeyres index offers in most cases only small improvements in accuracy over the base-weighted indexes. Table E suggests that the Laspeyres chainlinked index measures growth over the period 1987-1992 with bias reduced by only 4 percentage points in comparison with the base-weighted index. The estimated reduction over the period 1992-1998 is also 4 percentage points. Table G1 suggests that the reduction in bias on an annual basis is between 0 and 2 percentage points for most years. This is a consequence of the low bias estimates for the base-weighted index for this series.

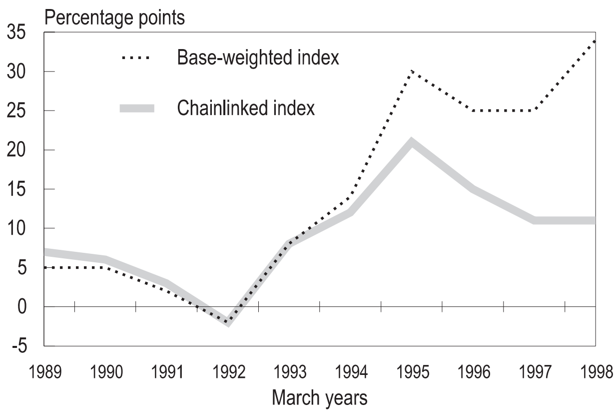
Table E suggests that for recent periods chainlinking offers larger improvements in accuracy for gross fixed capital formation. The estimate is that the chainlinked Laspeyres formulation measures growth over the period 1987-1992 with bias reduced by 3 percentage points in comparison with the base-weighted index. The estimated reduction in bias over the time period 1992-1998 is 93 percentage points. From table G5 it can be seen that the use of the chain Laspeyres index reduces the annual bias estimate by up to 16 percentage points.

Most of this reduction in bias is caused by the importance of computers in gross fixed capital formation. Relative prices for computers have tended to fall while volumes have risen more quickly for computers than for other capital goods. It was noted in section 3 that chainlinking can be expected to reduce the bias which occurs with the base-weighted series when relative prices and volumes change in this way.

Figure 2 compares the percentage point contribution of computers to growth in the chainlinked and base-weighted series. The difference between the contributions illustrates the approximate extent of bias in the base-weighted index attributable to computers. Over the period 1987-1992 (where chainlinking offered only a small reduction in bias) there is fairly little difference between the contribution of computers to growth in each index. The contribution of computers differs by more over the period 1993-1998 (where chainlinking offered a larger reduction in bias).

Figure 2

Contribution of computers to growth in gross fixed capital formation

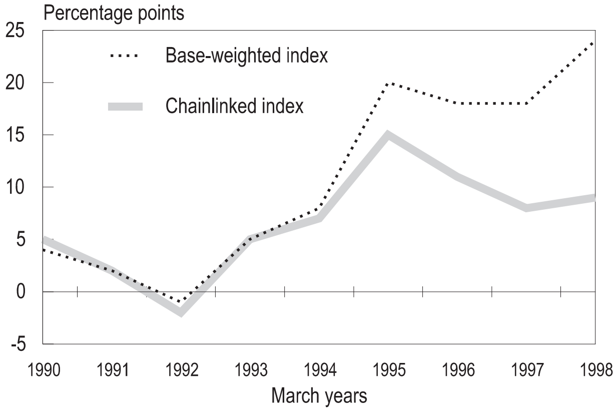


Because New Zealand imports most of its computer products, similar reductions in bias from chainlinking for the total imports series can be observed. From table E the estimate in the reduction in bias from using the chain Laspeyres index is 9 percentage points over the period 1987-1992, and 51 percentage points over the period 1992-1998. From table G7 it can be seen that this results from an estimated reduction in bias of up to 8 percentage points on an annual basis.

Figure 3 compares the percentage point contribution of computers to growth in the chainlinked and base-weighted total imports series. Over the period 1987-1992 (where chainlinking offered only a small reduction in bias) there is again fairly little difference between the contribution of computers to growth in each index. The contribution of computers differs by more over the period 1993-1998 (where chainlinking offers a larger reduction in bias).

Figure 3

Contribution of computers to growth in imports



The bias caused by series such as computers is large enough to be apparent in total gross national expenditure. Table E estimates the reduction in bias from using the chain Laspeyres index in favour of the base-weighted series at 7 percentage points for growth between 1987-1992, and 15 percentage points for growth over the period 1992-1998. Table G1 estimates the annual reduction in bias to be up to 5 percentage points.

Gross domestic expenditure shows lower bias than gross national expenditure because the biases in gross fixed capital formation and total imports offset one another.

Non-additivity

Back as far as 1987, the published base-weighted constant price indexes have the property of additivity. This means that the constant price value of each aggregate is equal to the sum of the constant price values of its components. For example, the value of total exports is equal to the sum of the export components.

Before 1987 there is generally a difference between the value of each aggregate and the sum of its components. The reason for the lack of additivity before 1987 is the link in this year. This is where the 1991 / 92-based series links with the previously published 1982 / 83-based series (refer Quarterly Gross Domestic Product: Sources and Methods, p. 34).

In general an index expressed in the prices of a particular year will be additive only as far back and forward from that year as the first link. The constant price indexes that Statistics New Zealand publish do not contain links after the base year 1991 / 92 and are additive to the end of the time series. The link in the series that exists in 1987 removes additivity before this year.

The indexes contained in this report contain annual links and are expressed in the prices of 1991 / 92. For this reason additivity exists only in 1991 / 92.[5]

Macroeconomic models that use constant price series for analysis often employ accounting relationships. Such models usually require additivity in the series entering the model. Adapting these models to allow for non-additivity in the series can be difficult. Indeed some countries (for example, Japan) cite the non-additivity of the indexes as the main reason why they have not adopted chainlinked volume series.

Some other countries including Australia and the United States have found that the benefits of annual linking in terms of increased index accuracy outweigh the costs of the non-additivity.

Statistics New Zealand will base the decision on how to proceed with chainlinking on the response of its users. Whether users believe the advantages of chainlinking exceed the cost of non-additivity is an important consideration.

Each of the tables in section 12 includes a column showing the discrepancy between the aggregate and the sum of the components.

The tables in section 12 show that the discrepancy between each component and the corresponding aggregate is zero in 1992 and tends to increase going back and forward in time. The reason for this is that 1992 is chosen as the expression base of the chainlinked indexes.

It is possible to use the fact that the discrepancy between aggregates and components is smallest near to the reference period to help deal with the problems caused by this discrepancy. By choosing the most recent complete financial year as the reference period the discrepancy for the most recent year can be removed. The discrepancy will also often remain small in recent years. This is the approach adopted by the Australian Bureau of Statistics. Should Statistics New Zealand continue to publish chainlinked series this option will be considered. The disadvantage of this approach is that it results in revisions to all previous index dollar values each time the reference year is updated.[6]

[5] Subject to the exceptions caused by the increase in stocks series as explained in this section.

[6] Note that only the index dollar values are affected - updating the reference period does not cause revisions to any growth rate.

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9. Tables

Differences in growth rates between base-weighted and chainlinked series for the main expenditure aggregates

Table F1

Gross domestic expenditure

Year ended March	Published base-weighted series growth from previous year (percent)	Chain Laspeyres index growth from previous year (percent)	Difference (percentage points)
1984	5.8	5.8	0
1985	5.2	5.2	0
1986	-0.2	-0.4	2
1987	3.3	3.5	-2
1988	0.8	1.1	-3
1989	1.1	1.5	-4
1990	-0.1	0.1	-2
1991	-0.8	-1.1	3
1992	-1.1	-1.0	-1
1993	0.8	0.8	0
1994	6.1	6.1	0
1995	5.3	4.7	6
1996	2.7	2.9	-2
1997	2.8	2.9	-1
1998	3.2	3.1	1

Table F2

Gross national expenditure

Year ended March	Published base-weighted series growth from previous year (percent)	Chain Laspeyres index growth from previous year (percent)	Difference (percentage points)
1984	3.6	3.6	0
1985	5.9	5.9	0
1986	-0.2	-0.4	2
1987	2.2	2.7	-5
1988	1.2	1.8	-6
1989	0.8	1.0	-2
1990	3.9	4.4	-5
1991	-2.5	-2.8	3
1992	-4.6	-4.6	0
1993	2.1	2.1	0
1994	6.1	6.1	0
1995	6.9	6.5	4
1996	4.2	4.2	0
1997	3.8	3.5	3
1998	3.9	2.7	12

Figure 4

Comparison of growth rates for Gross National Expenditure

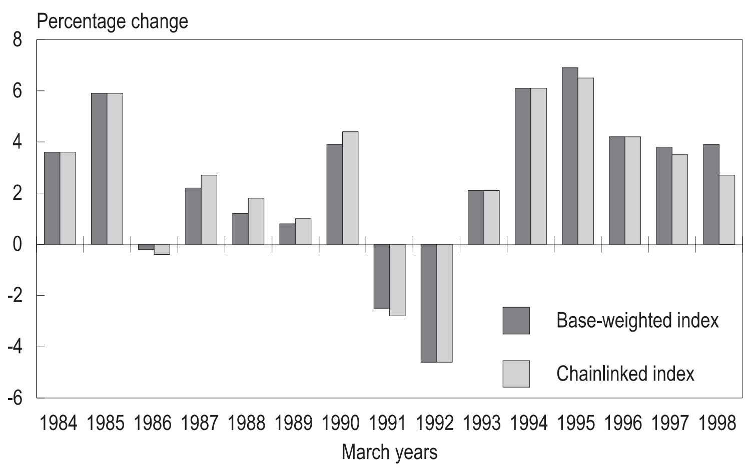


Table F3

Private final consumption expenditure

Year ended March	Published base-weighted series growth from previous year (percent)	Chain Laspeyres index growth from previous year (percent)	Difference (percentage points)
1984	3.1	3.1	0
1985	3.9	3.9	0
1986	1.4	1.3	1
1987	4.2	4.4	-2
1988	2.4	2.9	-5
1989	1.7	2.0	-3
1990	0.3	0.7	-4
1991	-0.3	-0.3	0
1992	-2.0	-1.9	-1
1993	0.3	0.3	0
1994	3.2	3.1	1
1995	6.1	6.1	0
1996	4.1	4.2	-1
1997	4.1	4.2	-1
1998	3.2	3.1	1

Table F4

Government final consumption expenditure

Year ended March	Published base-weighted series growth from previous year (percent)	Chain Laspeyres index growth from previous year (percent)	Difference (percentage points)
1984	2.7	2.7	0
1985	1.8	1.8	0
1986	1.7	1.7	0
1987	0.7	1.1	-4
1988	1.4	1.6	-2
1989	1.2	1.4	-2
1990	2.6	3.0	-4
1991	0.7	0.8	-1
1992	0.0	0.0	0
1993	3.0	3.0	0
1994	-1.1	-1.1	0
1995	-0.9	-0.9	0
1996	2.8	2.9	-1
1997	2.2	2.1	1
1998	6.4	6.2	2

Table F5

Gross fixed capital formation

Year ended March	Published base-weighted series growth from previous year (percent)	Chain Laspeyres index growth from previous year (percent)	Difference (percentage points)
1984	6.5	6.5	0
1985	5.6	5.7	-1
1986	6.9	6.8	1
1987	-5.7	-6.1	4
1988	3.5	4.7	-12
1989	-4.5	-4.3	-2
1990	7.5	7.2	3
1991	-5.2	-5.5	3
1992	-17.6	-17.6	0
1993	3.7	3.7	0
1994	18.2	18.2	0
1995	17.2	16.6	6
1996	9.3	8.0	13
1997	6.4	4.8	16
1998	2.8	0.5	23

Table F6

Exports

Year ended March	Published base-weighted series growth from previous year (percent)	Chain Laspeyres index growth from previous year (percent)	Difference (percentage points)
1984	6.1	6.0	1
1985	9.4	9.4	0
1986	1.7	1.8	-1
1987	4.6	4.8	-2
1988	7.3	7.0	3
1989	0.7	1.1	-4
1990	-2.4	-2.4	0
1991	6.4	6.8	-4
1992	9.3	9.5	-2
1993	2.5	2.5	0
1994	7.9	7.8	1
1995	8.4	7.7	7
1996	2.6	2.5	1
1997	3.8	4.1	-3
1998	2.4	2.1	3

Figure 5

Comparison of growth rates for gross fixed capital information

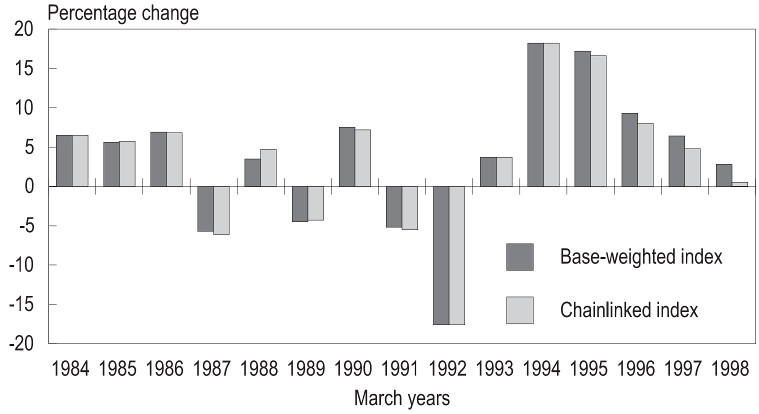


Figure 6

Comparison of growth rates for exports

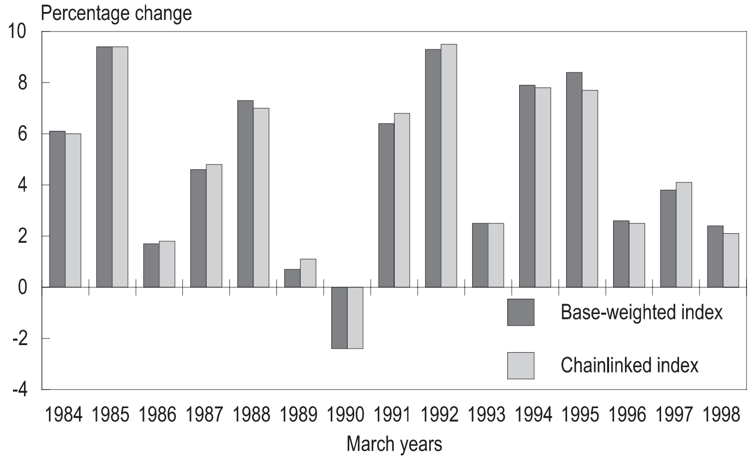


Figure 7

Comparison of growth rates for imports

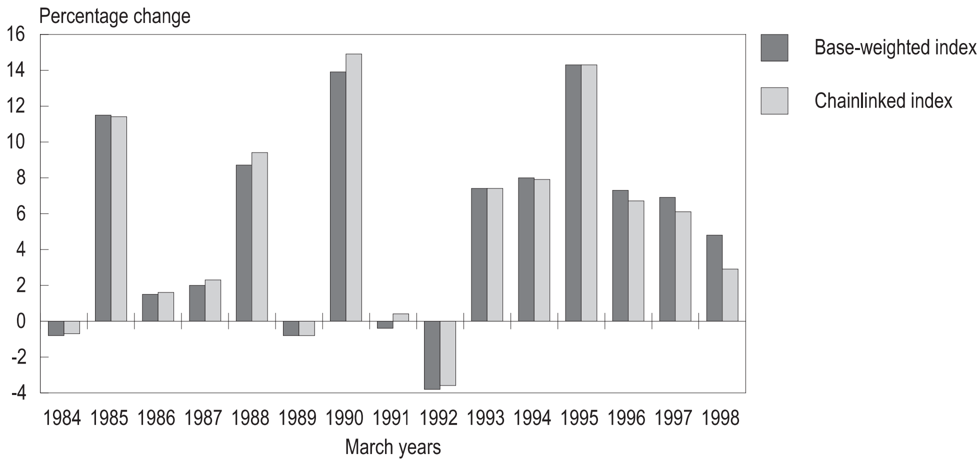


Table F7

Imports

Year ended March	Published base-weighted series growth from previous year (percent)	Chain Laspeyres index growth from previous year (percent)	Difference (percentage points)
1984	-0.8	-0.7	-1
1985	11.5	11.4	1
1986	1.5	1.6	-1
1987	2.0	2.3	-3
1988	8.7	9.4	-7
1989	-0.8	-0.8	0
1990	13.9	14.9	-10
1991	-0.4	0.4	-8
1992	-3.8	-3.6	-2
1993	7.4	7.4	0
1994	8.0	7.9	1
1995	14.3	14.3	0
1996	7.3	6.7	6
1997	6.9	6.1	8
1998	4.8	2.9	19

Comparison of potential bias in the base-weighted and chainlinked Laspeyres growth rates for the main expenditure aggregates

Table G1

Gross domestic expenditure

Year ended March (1)	Published base-weighted series growth from previous year (percent)(2)	Chain Laspeyres series growth from previous year (percent) (3)	Chain Fisher series growth from previous year (percent) (4)	Estimated bias in published base-weighted series (percentage points) (5)	Estimated Bias in chain Laspeyres series (percentage points) (6)	Estimated reduction in bias from chainlinking (percentage points) (7)
1988	0.8	1.1	1.0	-2	1	1
1989	1.1	1.5	1.4	-3	1	2
1990	-0.1	0.1	0.2	-3	-1	2
1991	-0.8	-1.1	-1.1	3	0	3
1992	-1.1	-1.0	-1.1	0	1	-1
1993	0.8	0.8	0.7	1	1	0
1994	6.1	6.1	6.1	0	0	0
1995	5.3	4.7	4.9	4	-2	2
1996	2.7	2.9	2.9	-2	0	2
1997	2.8	2.9	2.8	0	1	-1
1998	3.2	3.1	2.9	3	3	0

Table G2

Gross national expenditure

Year ended March (1)	Published base-weighted series growth from previous year (percent) (2)	Chain Laspeyres series growth from previous year (percent) (3)	Chain Fisher series growth from previous year (percent) (4)	Estimated bias in published base-weighted series (percentage points) (5)	Estimated bias in chain Laspeyres series (percentage points) (6)	Estimated reduction in bias from chainlinking (percentage points) (7)
1988	1.2	1.8	1.5	-3	3	0
1989	0.8	1.0	0.9	-1	1	0
1990	3.9	4.4	4.5	-6	-1	5
1991	-2.5	-2.8	-2.7	2	-1	1
1992	-4.6	-4.6	-4.7	1	1	0
1993	2.1	2.1	2.1	0	0	0
1994	6.1	6.1	6.2	-1	-1	0
1995	6.9	6.5	6.5	4	0	4
1996	4.2	4.2	4.1	1	1	0
1997	3.8	3.5	3.4	4	1	3
1998	3.9	2.7	2.7	12	0	12

Figure 8

Estimated bias in Gross Domestic Expenditure

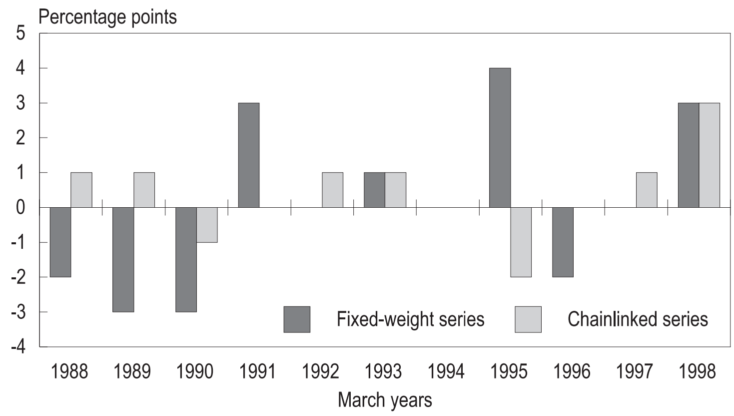


Figure 9

Estimated reduction in bias using chain indexes

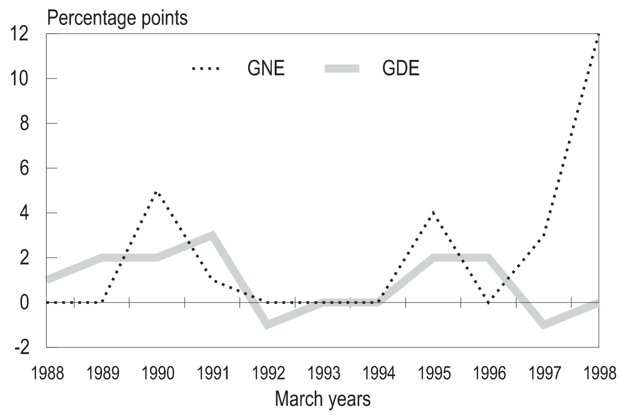


Table G3

Private final consumption expenditure

Year ended March (1)	Published base-weighted series growth from previous year (percent) (2)	Chain Laspeyres series growth from previous year (percent) (3)	Chain Fisher series growth from previous year (percent) (4)	Estimated bias in published base-weighted series (percentage points) (5)	Estimated bias in chain Laspeyres series (percentage points) (6)	Estimated reduction in bias from chainlinking (percentage points) (7)
1988	2.4	2.9	2.6	-2	3	-1
1989	1.7	2.0	1.9	-2	1	1
1990	0.3	0.7	0.5	-2	2	0
1991	-0.3	-0.3	-0.3	0	0	0
1992	-2.0	-1.9	-2.0	0	1	-1
1993	0.3	0.3	0.3	0	0	0
1994	3.2	3.1	3.2	0	-1	-1
1995	6.1	6.1	6.1	0	0	0
1996	4.1	4.2	4.2	-1	0	1
1997	4.1	4.2	4.1	0	1	-1
1998	3.2	3.1	3.2	0	-1	-1

Table G4

Government final consumption expenditure

Year ended March (1)	Published base-weighted series growth from previous year (percent) (2)	Chain Laspeyres series growth from previous year (percent) (3)	Chain Fisher series growth from previous year (percent) (4)	Estimated bias in published base-weighted series (percentage points) (5)	Estimated bias in chain Laspeyres series (percentage points) (6)	Estimated reduction in bias from chainlinking (percentage points) (7)
1988	1.4	1.6	1.5	-1	1	0
1989	1.2	1.4	1.4	-2	0	2
1990	2.6	3.0	2.9	-3	1	2
1991	0.7	0.8	0.7	0	1	-1
1992	0.0	0.0	0.0	0	0	0
1993	3.0	3.0	3.0	0	0	0
1994	-1.1	-1.1	-1.1	0	0	0
1995	-0.9	-0.9	-0.9	0	0	0
1996	2.8	2.9	2.8	0	1	-1
1997	2.2	2.1	2.2	0	1	-1
1998	6.4	6.2	6.4	0	-2	-2

Table G5

Gross fixed capital formation

Year ended March (1)	Published base-weighted series growth from previous year (percent) (2)	Chain Laspeyres series growth from previous year (percent) (3)	Chain Fisher series growth from previous year (percent) (4)	Estimated bias in published base-weighted series (percentage points) (5)	Estimated bias in chain Laspeyres series (percentage points) (6)	Estimated reduction in bias from chainlinking (percentage points) (7)
1988	3.5	4.7	4.4	-9	3	6
1989	-4.5	-4.3	-4.2	-3	-1	2
1990	7.5	7.2	7.3	2	1	1
1991	-5.2	-5.5	-5.8	6	3	3
1992	-17.6	-17.6	-17.3	-3	-3	0
1993	3.7	3.7	3.7	0	0	0
1994	18.2	18.2	18.0	2	2	0
1995	17.2	16.6	16.4	8	2	6
1996	9.3	8.0	7.8	15	2	13
1997	6.4	4.8	4.5	19	3	16
1998	2.8	0.5	1.1	17	-6	11

Table G6

Exports

Year ended March (1)	Published base-weighted series growth from previous year (percent) (2)	Chain Laspeyres series growth from previous year (percent) (3)	Chain Fisher series growth from previous year (percent) (4)	Estimated bias in published base-weighted series (percentage points) (5)	Estimated bias in chain Laspeyres series (percentage points) (6)	Estimated reduction in bias from chainlinking (percentage points) (7)
1988	7.3	7.0	6.9	4	1	3
1989	0.7	1.1	1.0	-3	1	2
1990	-2.4	-2.4	-2.7	3	3	0
1991	6.4	6.8	6.4	0	4	-4
1992	9.3	9.5	9.4	-1	1	0
1993	2.5	2.5	2.5	0	0	0
1994	7.9	7.8	7.4	5	4	1
1995	8.4	7.7	8.0	4	-3	1
1996	2.6	2.5	2.2	4	3	1
1997	3.8	4.1	3.8	0	3	-3
1998	2.4	2.1	2.1	3	0	3

Figure 10

Estimated reduction in bias for consumption and investment

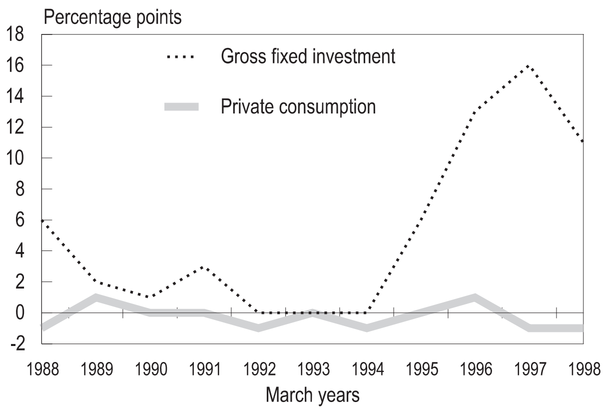


Table G7

Imports

Year ended March (1)	Published base-weighted series growth from previous year (percent) (2)	Chain Laspeyres series growth from previous year (percent) (3)	Chain Fisher series growth from previous year (percent) (4)	Estimated bias in published base-weighted series (percentage points) (5)	Estimated bias in chain Laspeyres series (percentage points) (6)	Estimated reduction in bias from chainlinking (percentage points) (7)
1988	8.7	9.4	9.3	-6	1	5
1989	-0.8	-0.8	-0.8	0	0	0
1990	13.9	14.9	14.4	-5	5	0
1991	-0.4	0.4	0.2	-6	2	4
1992	-3.8	-3.6	-3.7	-1	1	0
1993	7.4	7.4	7.4	0	0	0
1994	8.0	7.9	7.7	3	2	1
1995	14.3	14.3	14.1	2	2	0
1996	7.3	6.7	6.5	8	2	6
1997	6.9	6.1	6.1	8	0	8
1998	4.8	2.9	2.7	21	2	19

Figure 11

Estimated bias for exports

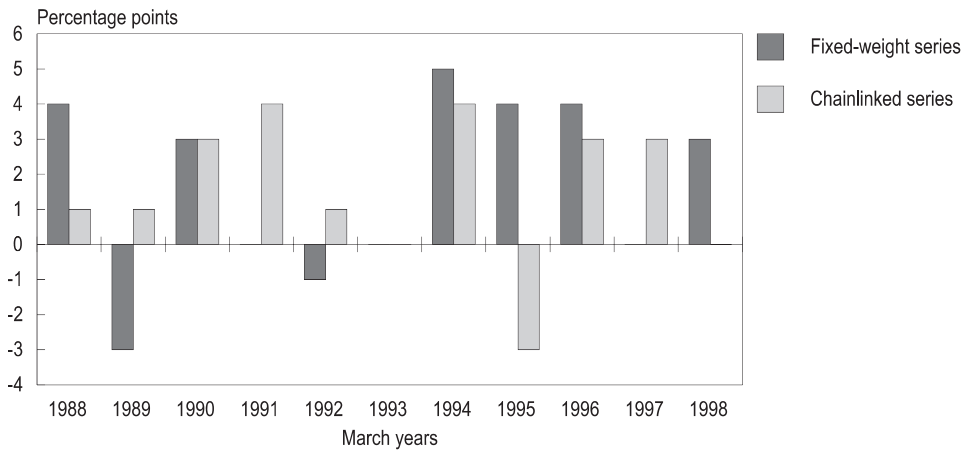
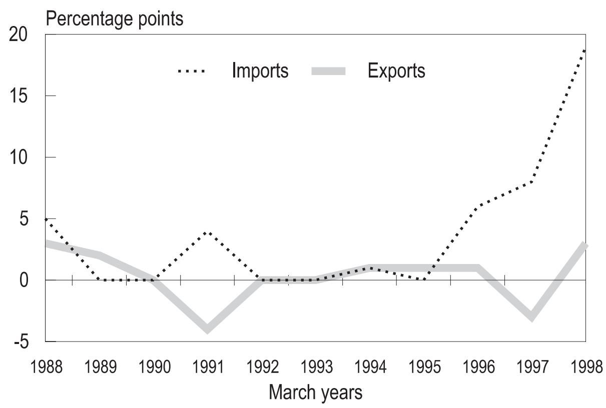


Figure 12

Estimated reduction in bias for exports and imports



10. Future Chainlinking Work at Statistics New Zealand

Following this release of chainlinked expenditure series, the next step is to examine chainlinked series for the production-based GDP by industry series.

The base-weighted constant price production-based measure of GDP tends to show less quarterly volatility than the base-weighted constant price expenditure measure. For this reason the production-based measure is the preferred series for quarter on quarter and annual changes. It is likely that chainlinked production-based series will also offer this advantage over the chainlinked expenditure-based series.

Calculating chainlinked production-based series poses practical and conceptual problems not faced when chainlinking expenditure series. Reasons for this include the more varied methodologies employed when forming the base-weighted production-based series, and the fact that current price series are often derived independently from the corresponding constant price series.

On balance, the decision to form chainlinked gross domestic product by industry series should be based on the possible benefits from chainlinking for these series.

The performance of the chainlinked expenditure series gives an indication of the likely effects of chainlinking "gross domestic product by industry" series. The analysis of section 8 suggests that chainlinking offers improved measures of growth for most expenditure aggregates. Table G1 estimates a reduction in bias from chainlinking of between 0 and 2 percentage points for expenditure on gross domestic product in most years. Similar reductions in bias from chainlinking can be expected for total gross domestic product which is conceptually equal to expenditure on gross domestic product.

The effect of chainlinking on individual gross domestic product by industry series is more difficult to predict. At the most detailed available level of aggregation, many of the base-weighted series are calculated using single indicators. Where this is the case the base-weighted and chainlinked series will be identical. Differences between base-weighted and chainlinked series can be expected for some series at the published production group level.

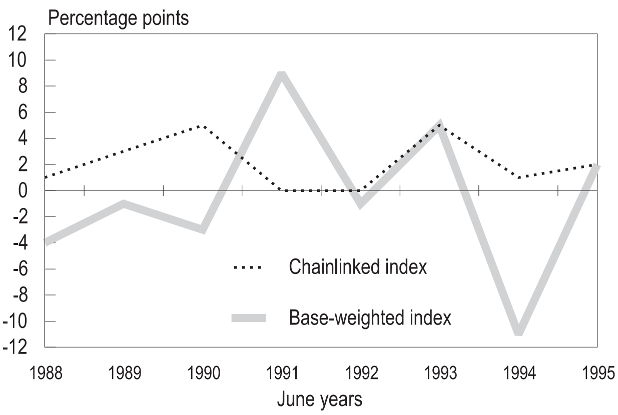
Chainlinking offered fairly large reductions in bias for the imports and gross fixed capital formation expenditure series - the result of large price and volume change for computers. These reductions in bias were not apparent for total expenditure on gross domestic product because they offset one another. It is possible that similar offsetting effects could occur within individual series for gross domestic product by industry. For example, chainlinking could cause relatively large reductions in bias for some industries but increase bias for others. If this were the case, total gross domestic product could show only the expected small reduction in bias from chainlinking.

Statistics New Zealand has published annually-chainlinked Laspeyres volume indexes for farming production.[7] These indexes were calculated on a June-year basis. The performance of this production-based index provides some insight into the benefits of chainlinking other production-based series. The table and graph below estimate and compare bias in the published chainlinked volume index for total farming and an unofficial base-weighted index in 1991/92 prices which has been calculated using the same component data. The chainlinked index appears to offer a reduction in bias over the base-weighted index, particularly in recent years.

Given the apparent gains in accuracy from chainlinking expenditure series and the farming

Figure 13

Estimated bias: farm production series



[7] Refer *New Zealand System of National Accounts 1997*, table 2.11, page 61.

Table H

Year ended June	Published base-weighted index growth from previous year (percent)	Published chain Laspeyres series growth from previous year (percent)	Chain Fisher series growth from previous year (percent)	Estimated bias in published base-weighted series (percentage points)	Estimated bias in chain Laspeyres series (percentage points)	Estimated reduction in bias from chainlinking (percentage points)
1988	5.6	6.1	6.0	-4	1	3
1989	-3.2	-2.8	-3.1	-1	3	-2
1990	-0.4	0.4	-0.1	-3	5	-2
1991	4.2	3.3	3.3	9	0	9
1992	0.9	1.0	1.0	-1	0	1
1993	-0.6	-0.6	-1.1	5	5	0
1994	9.9	11.1	11.0	-11	1	10
1995	0.1	0.1	-0.1	2	2	0

production index, it seems likely that increases in accuracy from chainlinking gross domestic product by industry series will be small but positive. Statistics New Zealand will therefore attempt to form chainlinked estimates for these series. It is intended that the chainlinked gross domestic product by industry series will extend back to June 1977 (the start of the time series of constant price series). Both annual and quarterly series will be calculated. The quarterly index will be published reconciled to the annual.

Following the release of chainlinked production-based series, Statistics New Zealand will decide whether to continue chainlinking work based on the response of users. Several options for further work exist. These include:

- Periodically updating the chainlinked series as experimental series. This could occur annually with the incorporation of annual constant price estimates into the published series, or quarterly to supplement the official constant price series.
- Adopting chainlinked series as official statistics. This would require a full analysis of the seasonal adjustment of these series.

11. References

Papers referred to in this report are:

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

Diewert, W.E. (1995), *Price and Volume Measures in the System of National Accounts.* The University of British Columbia. Discussion Paper No. 95-02. January 1995.

Fisher, I. (1921), *The Best Form of Index Number.* Quarterly Publication of the American Statistical Association, pages 533-51, March 1921.

Landefeld, J. S., and Parker, R. (1995), *Preview of the Comprehensive Revision of the National Income and Product Accounts: BEA's New Featured Measures of Output and Prices.* Survey of Current Business, July 1995.

Other useful references include:

Hill, P., *Recent Developments in Index Number Theory and Practice.* O.E.C.D. Economic Studies 10, pages 123-148, Spring 1988.

Johnson, L., *Choosing a Price Index Formula: A Survey of the Literature with an Application to Price Indexes for the Tradable and Non-Tradable Sectors.* ABS Working Paper No. 96/1, Cat. No. 1351.0, May 1996.

Statistics Canada, *A Technical Note on Laspeyres, Paasche and Chain Price Indexes in the Income and Expenditure Accounts.* May 1989, Ottawa.

Statistics Canada, *Volume Indexes in the Income and Expenditure Accounts.* August 1990, Ottawa.

Samuelson, P.A. and Swamy S., *Invariant Economic Index Numbers and Canonical Duality: Survey and Synthesis.* The American Economic Review, pages 566-593, September 1974.

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12. Statistical Tables

A complete set of statistical tables presenting experimental chainlinked series in 1991/92 prices.

See attached excel file tables.xls.