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Teaching Index Numbers to economists

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Abstract: Economic statistics are frequently reported in the form of index numbers. This article considers how the field of Index Numbers should be approached in the teaching of a general economic degree. While the topic finds a natural home in statistics modules, it is emphasised that the area can also be referred to in the teaching of other areas of economics. It is also emphasised that the differences between Index Numbers theory and the practice of compiling economic statistics such as inflation can help students gain a better understanding of applied economic statistics. Methods for assessing learning in the area are also considered and available material to support teaching is also summarised.

Subjects: Teaching & Learning; Economics; Education; Statistics for Business; Finance & Economics

Keywords: Index Numbers; economic statistics; official statistics; inflation; economic tools for teaching

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1. Introduction

Index Numbers[1] methods are among the most commonly used statistical techniques in the area of economic statistics. Index Numbers are commonly used to combine large amounts of data about a given variable into a single number; the variable is then (usually) allowed to vary over either a spatial or temporal dimension. Statistics measured using some type of index number include, inflation, stock market performance, volumes of production and human development. Despite the widespread applied use of tools which fall under the heading of index numbers, the area is typically taught to economics undergraduates within a first-year statistics course in which a few formulae are introduced and then little emphasis is given to the subject area in other modules or in later years.

In this article, I will attempt to describe an alternative approach to the teaching of index numbers. It is argued that it is beneficial to move beyond the application of a small set of formulae to artificial

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Robert O'Neill is a senior lecturer in Economics at the University of Huddersfield. Prior to taking up this position, he worked for the Office for National Statistics as part of the Index Numbers methodology team. He has recently published a book, alongside two of his former colleagues on the topic of Index Numbers. In addition to research in this area, he maintains an active interest in volatility forecasting for financial asset portfolios.

PUBLIC INTEREST STATEMENT

Index Numbers methodology is used to create many of the economic statistics we see quoted in the news on a regular basis, often they are used to measure changes in prices or economic activity compared with some prior period. This paper discusses how economists might go about teaching the subject to inexperienced colleagues and attempts to highlight linkages with other areas of economics as well as highlighting the differences students might encounter when applying theory in the real world. Although this article does not introduce the unfamiliar reader to the subject of Index Numbers, it does recommend a number of sources which may be of interest to an individual who wants to know more about this area.

data and consider that a deeper appreciation of Index Numbers can provide economics students with a better understanding of the link between theory and application in the area of economic statistics. The proposed approach will enhance students' understanding of both the strengths and weaknesses inherent in the statistics produced by National Statistical Institutions such as the Office for National Statistics (ONS) in the UK. A better understanding of this environment will then potentially fuel their understanding of applied work in other areas of economics and make them better placed to analyse and make use of other economic statistics.

Sections 2 and 3 of this article highlight what might be taught to economics students in the area of Index Numbers with a distinction drawn between the theoretical matter of approaching the area and issues which might be raised relating to the application of the theory in the world of applied economic statistics. Assessment of these key areas is then briefly discussed before linkages between a statistical introduction to Index Numbers and other core areas of an economics syllabus are briefly reviewed. Section highlights materials and resources which may be useful to students and lecturers at various levels of an economics education.

2. Index Numbers theory

This section will deal with the subject matter which might be introduced to economics students studying Index Numbers under the heading of "theory", generally this will be used to capture all material which is not explicitly linked to the compilation of a set of index numbers from sampled data and includes the construction of indices from idealised data. We might think of the material discussed in this section as forming an introduction to the world of Index Numbers in which there are no restrictions on data and in which everything required for an index will be knowable.

The natural home for an introduction to the use of index numbers in economics courses is in a first-year statistics module. This is facilitated by the fact that Index Numbers requires little technical sophistication beyond that which would be found in most secondary education mathematics course. For example, two of the simplest indices, the Dutot and Carli indices, require nothing more than the use of arithmetic means, the Laspeyres and Paasche formulae make use of basic arithmetic skills, while the Fisher and Jevons indices require only the ability to raise totals to the second and *n*th roots, respectively. The core Index Number formulae are reproduced below for reference in Table 1, where the price of the *i*th good at time *t* is represented as P_{it} and quantity as Q_{it}.

It is worth noting that introductions to the topic of Index Numbers often rely on applied examples as offering students a definition of an index number is difficult and no satisfactory formal definition has been identified which adequately introduces the method intuitively.[2] When using Index Numbers, economists generally attempt to combine multiple pieces of data into a single number which informs us about the change in the level of some variable over some well-understood dimension. It

Table 1. Index Number formulae

Formula name	Formula
Carli	$\frac{1}{N}\sum_{i=1}^{N}\frac{P_{i1}}{P_{i0}}$
Jevons	$\left(\frac{P_{i1}}{P_{i0}}\right)^{1/N}$
Dutot	$\frac{\frac{1}{N}\sum_{i=1}^{N}P_{i1}}{\frac{1}{N}\sum_{i=1}^{N}P_{i0}}$
Laspeyres	$\frac{\sum_{i=1}^{N}P_{i1}Q_{i0}}{\sum_{i=1}^{N}P_{i0}Q_{i0}}$
Paasche	$\frac{\sum_{i=1}^{N}P_{i1}Q_{i1}}{\sum_{i=1}^{N}P_{i0}Q_{i1}}$
Fisher	$\sqrt{\text{Laspeyres} \times \text{Paasche}}$

is therefore unsurprising that examples such as measuring changes in the price level over time, how income changes across countries or how production quantity varies across regions are required to introduce the subject.

There are several potential starting points for the study of Index Numbers and a natural one for economics students will be to consider the Index Numbers problem. The Index Numbers problem poses the question of how to decompose changes in values into contributing changes in quantity and price. This can be introduced via a small-scale problem similar to that introduced in Table 1, In this example, expenditure increases and this is mainly driven by an increases in the quantities purchased. The numbers in such an example can be characterised as expenditures or revenues and an initial index can be constructed which shows the relative change in the total between the two time periods. As a next step, students can then be introduced to the idea that this change is driven by two effects, a price effect and a quantity effect. Given this starting point, students' introduction to the various available formulae can be driven by delving into the change in this simple value index.

Having been introduced to the concept of a value index and shown some examples, students can then progress onto considerations of price and quantity relatives and from there move on to the various ways in which the information can be combined to produce a series of index numbers. Once the formulae have been introduced, it may be the case that students think little more about the use of formulae in the construction of economic statistics, treating their use as an extemporaneous choice. However, Index Number theory may well go further to describe and compare the different conceptual bases across which to make a choice between formulae. Such a comparison may be beyond students on an introductory statistics course who view such subjects as an exercise in learning how to apply various tools to data.

The formulae themselves can be practised with the aid of a relatively small data-set, and this can be related to students' own personal experience, for example, estimating the changing cost of an evening out over a time period.[3] An example of such a data-set is provided in Table 2 for stationery items though students may be encouraged to populate such an example from their own experience.[4]

While teaching index numbers to various groups, including undergraduates and those studying for the Royal Statistical Society (RSS) Higher Certificate, myself and colleagues have found that there is no better method for getting to grips with what the indices are trying to do than to have students calculate index numbers for themselves. As the formulae are generally very similar and errors in mixing up time periods are common, this will almost inevitably lead to some miscalculations. Despite encountering errors and having constructed a set of index numbers by hand, students should then be better placed to discuss what the indices are doing and appreciate the difference between them. It is also worth noting that this would have been close to the technique used when the Retail Prices Index was first introduced as a measure of the price level in 1947, and help students to appreciate the need for software which will speed up the process for much larger data-sets.[5] Students might well be asked to estimate Carli, Dutot, Jevons, Paasche, Laspeyres and Fisher indices.[6] As an additional bonus students can also estimate quantity indices from the data in Table 1, which means a relatively small data-set can generate a large set of applied examples for students to work on.

Table 2. Example data for an Index Numbers exercise

	2010		2014	
Item	**Quantity**	**Price**	**Quantity**	**Price**
Book	10	10	6	11
Notepad	4	5	12	6
Ebook	6	9	16	8.5
Bookmark	5	1	1	0.5

Once students have been introduced to the practicalities of calculating index numbers, they are likely to find it easier to perform algebraic manipulations of Index Numbers formulae. For example, it is relatively easy to show that a value index can be decomposed into a Laspeyres Price index multiplied by a Paasche Quantity index as is showing that a Laspeyres index is a base period expenditure weighted average of price relatives. The ability to go beyond cranking through the calculations into this sort of algebraic manipulation of the formulae is likely to prepare students to discuss choices between index numbers in more depth. The algebraic manipulations required for this sort of work may also provide a relatively safe environment in which students can practice the algebraic manipulation of summation symbols, thus preparing them for more complex work at a later date.

An important factor in the study of index numbers has been the ways in which economists and institutions have argued for the use of different formulae. This requires students to think analytically about choices in statistical methodology and is a logical next step in the discussion of the range of formulae which may be utilised in the preparation of an index. The introduction of the economic, axiomatic and statistical approaches[7] allows for a wider discussion of how economic statistics are applied in the real world, which would be especially useful for students who intend to pursue a career in this area as the argument surrounding this area is indicative of similar issues in other similar areas.

Having considered how index numbers are constructed, students can be introduced to their uses, for example, deflating series of values so that real growth is identified. It is also straightforward to demonstrate how index numbers can be re-referenced in order to make several series more comparable. In addition the practice of uprating payments by indices can be demonstrated, which will be useful in highlighting the compounding effects of relatively modest rates changes in an index. The process of using an index number in this manner, having discussed the choices involved should provide students with a more thorough understanding of the options available when constructing a theoretical index. Having knowledge of how to approach the choice between the various options as well as demonstrating some knowledge regarding how the resulting estimates will be used in practical circumstances will add to students understanding of the topic beyond a simple recitation and application of formulae.

3. Index Numbers and applied economic statistics

Students studying Index Numbers can be introduced via this topic to the difficulty of producing accurate and useful economic statistics in a timely manner and the practical trade-offs required in the real world of economic statistics and the potential techniques which may be needed to balance these competing aims. It might be possible for students to run their own price collection experiment around campus to see some of these issues in practice. However, this may be a time-consuming process for such a relatively minor topic. The difficulties of producing statistics in a timely manner are one which may help students to question official statistics more vigorously. There are several issues related to the compilation of index numbers by ONS which are well documented and can be used to explain and highlight the range of potential issues in compiling Official Statistics. More details can be found in ONS (2015a). However, a brief summary of some such issues can be detailed here:

- Goods to be included in an official basket of goods should be representative of consumer habits. How might this be done, especially for new goods for which there is no current data, the annual basket refresh is useful to demonstrate this (see ONS, 2015b).
- Collection of prices on a regular basis on "index day" can be used to demonstrate several sampling issues. Further issues such as the non-availability of goods, or how special offers should be recorded raise additional problems for compilers of index numbers.
- What populations should an index cover, for example, should the Consumer Price Index (CPI) include spending by non-residents in the UK, should it include spending by residents when abroad? Should the RPI exclude people at the extremes of the income distribution as it does?

- How should items be categorised (this could be used as an introduction to standard industrial classifications)
- How to compile an index of prices when the items under consideration are not sold regularly, such as in the case of the House Price Index?
- How to standardise the cost of providing a service in the case of an industry such as civil engineering or accounting to determine changing price and quantity levels?
- The trade-offs between time and accuracy in production, for example, many house price indices are published prior to the release of the ONS figures. However, they are inevitably based on a smaller data-set and less transparent methodology.
- The practice of refreshing the index on a regular basis, thus requiring a chain linking together of individual data series, as is done for most official index series.

All of the above provide examples of issues which may affect the compilation of an index and may make it clear that the closed, well-defined world discussed when introducing Index Number theory is rarely a good approximation of the applied environment economists are likely to find in the real world. Although this point can be made with a number of statistical measures and their empirical applications, it is worth stressing when teaching Index Numbers as students are likely to see regular news reports which rely on these sorts of statistics and this coverage can be used to frame some discussion of these issues.

It may be possible to highlight all of the above issues in the application of Index Number theory by asking students to compile their own index which will measure the change in price level for students between two areas or across two time periods. This would allow them to document any difficulties they had and force them to document any assumptions they had to make during the process. Given even a limited data-set, students would be able to compile some index numbers while commenting on the difficulties of producing statistics in line with theory.

As well as discussing the issues related to constructing indices, it might also be useful for students to consider the range of different uses to which these indices might be put beyond academic analysis of the economy. Students may be able to discuss the various ways in which businesses, policy-makers, researchers, journalists and individuals might be able to use indices in their various spheres. A good example to illustrate how this might not always be straightforward is to consider the government's use of two different measures of inflation for indexing payments negatively affecting government financing (benefits, tax allowances) using a generally higher rate than payments positively affecting public finances (student loan payments, train fares, GILT interest).

Students who are not exposed to the practical problems and considerations of compiling Index Numbers in the real world may feel that the topic is of little interest to those other than statisticians. This is unlikely to be the case as most economists are likely to make use of numbers produced using an Index Numbers approach and economists should be able to assess the appropriateness, accuracy and representativeness of these statistics based on the statistical methodology used to produce them, which will almost always differ from a simple application of one of the formulae introduced above.

Students approaching theses applied problems for the first time may be daunted to some extent by the issues and a good grasp of the ideas behind them, such as sampling approaches for price collection and multiple regressions for pricing of complex items via hedonics, is required. For this reason, it is suggested that the type of discussion outlined above might only be undertaken in detail with students who have already completed a course in statistical foundations, although students can be introduced to at least some of the material on a first encounter with Index Numbers.

It is worth noting that as "Big Data" becomes more of an issue in the area of economic statistics Index Numbers provides an area to discuss practical applications of large data-sets. This is aided by the work of the ONS Big Data project using web-scraped data (see ONS, 2015c for more information) and the work of the Billion Prices project (see http://bpp.mit.edu/ for details). Most students should be comfortable discussing this material once they have mastered the basics of price indices and so it might be thought that this area provides a safe environment in which to discuss issues related to increased data-set sizes, a topical issue for those handling data and producing analysis.

4. Assessing learning in index numbers

Students will naturally engage with teaching directly focused on a technical topic such as Index Numbers at a range of levels. There are a number of ways of assessing how students have attained these different levels and in Table 3 a description of levels of learning for the subject area is proposed.

In order to assess the different levels of learning a strategy is needed which allows weaker students to show that they have attained the basic level skills while allowing advanced students a chance to develop further. The obvious first step is to allow students to calculate one or two index numbers. This might then be followed by a question asking students to perform an algebraic manipulation of formulae and state what the result means in words. Higher and advanced level skills can be demonstrated via questions which might ask students to comment on the choice between two competing Index Numbers formulae and comment on why an index number drawn from a data-set similar to that in Table 2 is unlikely to be appropriate for use in a high-level economic analysis. A range of potentially useful example exam questions which follow a similar format to this can be found in past RSS higher papers which include an Index Numbers component.[8]

The suggested framework is most obviously suited to an examination question split into parts. However, learning in Index Numbers might also be assessed via assignment. This might take the form of a report which asks students to describe the calculation methods used in an index of their choice and comment on the choices made in construction of these statistics. A more involved project might require students to collect or source data with which to construct an index of their own before commenting on the methodology they have chosen to employ and the potential uses to which their index might be put. This exercise would bring students closer to the practice of compiling economic statistics for end users, while also allowing assessment of learning in other areas such as sampling at the same time as assessing learning in index numbers.

Table 3. Levels of achievement for Index Numbers learning

Level of understanding	Description of ability outcomes
Basic	Able to use data to estimate index numbers from a formula and able to state the main finding resulting from the index
Intermediate	In addition to the Basic level skills, students are able to manipulate and interpret different forms of index numbers, also able to describe different methods for choosing between formulae.
Higher	In addition to Intermediate, able to discuss and analyse the relative properties of various index numbers as well as identify appropriate real-world applications of the technique.
Advanced	In addition to Higher, able to discuss the practical trade-offs which might affect the use of index numbers in practice and able to assess uses of index numbers as appropriate or not.

5. Index Numbers other than inflation: spatial indices, human development and more

Index Numbers are most commonly encountered in early discussions of inflation measurement across time. However, it is also possible to emphasise to students the varied ways in which index numbers can be used in Economic Statistics. The International Price Comparison Programme (ICP) (http://siteresources.worldbank.org/ICPEXT/Resources/ICP_2011.html) collects price statistics over a spatial, rather than temporal dimension and can be used as a statistical approach to a consideration of purchasing power parity. Again the applied difficulties of such an exercise can be used to motivate more discursive sessions on the compilation of such statistics. For example, in the ICP, there are regional link countries to circumvent the problem of not all countries having common goods for sale, due to differences in translating into different languages and dialects pictures are issued to price collectors, etc. Expanding the discussion of index numbers in one dimension therefore raises a number of other issues which need to be considered.

As well as producing a wide range of price indices, the ONS also compile a number of quantity indices might be used to illustrate how Index Numbers is put to use in economic statistics. The Retail Sales Index (RSI) measures the volume of purchases by consumers and is often in the news relating to high street expenditures around Christmas, the Index of Production measures manufacturing output across the UK while several Gross Domestic Product (GDP) series are reported as volume indices (indeed the raw material is deflated by another ONS produced price index - the GDP deflator.) Sometimes, the range of quantity indices produced by National Statistical Institutions is given less attention than price indices in the Index Numbers literature. However, it is important to include such indices in an economists' introduction to the subject as these indices will be more focused on identifying variations in real economic activity and so should be of more fundamental interest.

The Human Development Index, http://hdr.undp.org/en/content/human-development-index-hdi, uses an Index Numbers methodology to combine several statistics, several of them which are themselves indices. This provides a good example of the ways in which Index Numbers may also be put to use in the study of development economics. The Human Development Index represents just one way in which Index Numbers methodologies can be put to a wider use and might be used to stimulate discussion of the potential wider uses of the methodology.

6. Index Numbers in macro, micro and economic history courses

Various areas of economics teaching make use of index numbers (or variables which are often captured using the technique in their applied setting) and this can be reinforced in a range of ways on modules outside of statistics modules. It should be clear that it is not proposed that Index Numbers methodology become a key concern in such modules. However, the topics first met in the statistics environment might be better understood as they are re-inforced in other economics modules. Again this will help develop students' wider thinking about the issues affecting economic statistics they may use or read about in the future.

6.1. Micro

Arguments which make use of microeconomic theory have been important in the development of index numbers, particularly in the measurement of inflation. A distinction is drawn in the statistical literature on the use of Index Numbers in measuring inflation between a "Cost of Goods Index", which measures the change in price of a fixed list of goods an services, and a "Cost of Living Index" which measures the change in price of attaining a constant level of utility. The "Economic Approach" to index numbers has generated much debate between Index Numbers practitioners, and ideas met in microeconomics are important for understanding these arguments. The concept of a Cost-of-Living price index, first formally considered in Konus (1924), which measures the required change in income to maintain a fixed utility level, is directly motivated by consideration of expenditure functions and substitution behaviour. Therefore, it would be difficult to introduce constant utility indices to students unfamiliar with these concepts.

Before discussing a formal definition of a Cost of Living Index, based on expenditure functions, it is possible to show students that the Laspeyres and Paasche formulae represent upper and lower bounds for a cost-of-living index for a rational consumer.[9] It is quite straightforward to show students, who are familiar with the underlying material, that the Jevons index represents a cost-of-living index for an individual with a Cobb-Douglas utility function where taste parameters are all set to be 1 / *n* in an *n* good setting. This result has itself been the basis for several users of index numbers to conclude that this index will better represent a cost-of-living index than other unweighted indices.[10] These arguments can be taken further as students are exposed to more complex utility functions, for example, Balk (1999) derives a cost-of-living index for a constant elasticity of substitution utility function. Similar issues might be discussed for producers. However, it remains clear that there are ways in which the potential use of index numbers might be emphasised even within microeconomic discussions. Concepts such as elasticity of substitution, the impact of new goods on demand for existing goods, the potential difficulties of identifying representative goods are all also potential areas of microeconomics which can be related back to the construction of an inflation measure.

The above discussion considers how Index Numbers might be discussed in a microeconomic course. While it would clearly not be a central part of such a course the suggested more formal introduction of economic theory into the Index Numbers environment will serve students well in two senses. Firstly, students will understand the formal theory behind the motivation to understand inflation and incorporate this into their broader understanding of Index Number theory. Secondly, such a discussion will greatly assist in the discussion of practical issues affecting Index Numbers, for example, how to measure utility, how to measure substitution behaviour, what can be done to approach estimation of a Cost-of-living index as might be required by economists. Such reinforcement and discussion of material across modules should further reinforce how economic theory should inform economic statistics and how the real world often prevents a straightforward application of the theory.

6.2. Macro

By necessity, the study of macroeconomic theory often proceeds without a deep consideration of the economic statistics which might be used and it would be rare for such a course to spend much time in the consideration of Index Numbers. I would not propose that this change however applied macro-economists are likely to use index number series more than most economists and it would be good to emphasise that the choice of Index Number might influence how things are seen.

A good example of this from the recent history of inflation measurement relates to the impact of the financial crisis on mortgage interest payments (MIPs). As the RPI incorporates MIPs, there was a concurrent downward shift in RPI inflation which was not matched by a fall in the CPI. Similarly, as GDP growth in the UK has been close to zero in recent years, this has prompted a discussion regarding the amount of error in the measurement in GDP growth. Similar arguments might be discussed regarding inflation statistics and production measures which might prompt macro-economists to treat official statistics with more suspicion than in the case in which NSIs' measurement of GDP, etc. is assumed to be consistent with the theoretical definitions of these variables.

As one of the primary end users of economic statistics macroeconomists should be aware of the strengths and deficiencies in official statistics. It would be hoped that by studying Index Numbers and the arguments surrounding the implementation of such methods that students might be more questioning of the tools which they use in an applied macroeconomics environment. This might result in some difficult questions when introducing applied subject matter but would support integration of statistical learning within macroeconomic modules and, as in the microeconomics case, help students in embedding the statistical knowledge within their wider knowledge of economics.

7. Resources to support teaching index numbers

There are several useful resources which are available to support the teaching of index numbers and to allow students to move beyond the introductory material. Until recently Allen (1974) was the

standard introductory text, however the more contemporary Ralph et al. (2015) introduces the topic without the requirement for much mathematical background, including a number of worked examples and exercises which may be useful for less confident students. Good introductory material can also be found in the International Labor Organisation (ILO) manual (ILO, 2004), which is freely available, particularly chapters 1, 2 and 15, although it should be noted that this might contain rather more detail than some students will want. The manual has been compiled by academics and practitioners in the field of Index Numbers and is a rich resource for anyone interested in the subject. In addition, recent issues affecting inflation estimation in the UK has led to a detailed review of the use of index numbers in this environment by the head of the Institute for Fiscal Studies and the resulting report is likely to be accessible to anyone who has had an introduction to index numbers (Johnson, 2015).

For more advanced students, there are a range of texts available which require differing degrees of mathematical competency. Diewert and Nakamura (1993) is perhaps the most natural source for students of economics, and includes biographical information on the key thinkers in the early development of index numbers. von der Lippe (2007) is much more technical, however deals with several more challenging issues in depth, while Balk (2008) is also useful. The more technical and detailed chapters of ILO (2004) are also likely to be of interest in discussing more technically complex applied material, such as the use of hedonic regressions in index construction, and so this remains a rich potential source of information throughout a student's study the subject: Fisher (1922) remains the most important historical source on index numbers, it also set the course for arguments which remain relevant today and so is still likely to be important for students considering a more thorough examination of the subject area.

Although compiled on a less formal basis than books and journal articles, it is also useful to note that statistical institutions which compile indices often also publish documents explaining their index construction. These can be useful guides to students regarding index numbers construction as well as a good introduction to how the theory of economic statistics might compare with the theory. Good examples of documents which explain index numbers from the producers' view for the UK include the CPI technical manual (ONS, 2015a) and a description of the construction of the house price index (ONS, 2013).

In various parts of teaching index numbers, it is useful to have access to real-world data to motivate examples. Fortunately, ONS make much of the data available in some form. Price quotes and item index data are available from the ONS website (http://www.ons.gov.uk/ons/guide-method/user-guidance/prices/cpi-and-rpi/cpi-and-rpi-item-indices-and-price-quotes/index.html), while detailed time series of price indices (e.g. the CPI http://www.ons.gov.uk/ons/datasets-and-tables/data-selector.html?dataset=mm23) and quantity indices (e.g. retail sales index http://www.ons.gov.uk/ons/rel/rsi/retail-sales/july-2015/tsd-retail-sales--july-2015.html) are also available.

8. Summary

Index Numbers is not an area of economics which immediately appears interesting to many students, it is however an important part of an economist's applied toolkit and is one which can be misused or misunderstood if not properly considered. The wide range of applied situations in which Index Numbers methodology is employed means that this subject also provides a strong link between the study of first concepts, theory and applied statistical practice. It benefits from the fact that an essential basis for understanding the area can be built quickly and the mathematical operations required are less daunting than in other areas of economic statistics.

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Notes
1. It should be noted that the capitalised, Index Numbers, is used to refer to the subject area under discussion

while the uncapitalised version, index numbers, is used to refer to the series of numbers produced by implementation of such a methodology, this is consistent with the Index Numbers literature.

2. Borowski and Borwein (2002) offer the following definition of an Index Number: "a measure of the change, relative to some specific base period, in some variable, such as the price, volume or value of a commodity, the gross national product, or the general level of prices". This does not allow for an easy inclusion of spatial indices, it also seemingly precludes comparison with non-base periods.
3. Historically, this is also very close to the first known use of an index number by Bishop Fleetwood in Chronicon Precosium, who used the method to calculate how much his annual living allowance should have been increased (for more information see Balk, 2008)
4. One exercise which has worked well in small group environments is to gather data on students expenditure on an evening out and compare the prices and quantities to the lecturer's data from when they were an undergraduate.
5. Given the nature of the calculations, it should also be quite simple to design exercises in a programming language such, as *R*, which will allow students to generate results from such software without requiring commands which go further than straightforward manipulations of vectors and a set of results can be obtained with just a few lines of code.
6. In fact, almost any index number proposed in the literature for measuring inflation can be estimated from the small data-set in Table 2, a noted exception being the Lloyd–Moulton index first proposed in Lloyd (1975).
7. See Ralph, O'Neill, and Winton (2015), Appendix B, for a discussion of the different ways of determining which of the available formulae to use.
8. Past RSS papers can be located at http://www.rss.org.uk/RSS/pro_dev/Examinations/key_information/Exam_past_papers/RSS/pro_dev/Examinations_sub/key_information/Exam_past_papers/Past_papers_and_solutions.aspx?hkey=a9bb93ab-66e5-4268-8faa-9c4251c35b16.
9. See Appendix B.2 of Ralph et al. (2015) for a demonstration of this and other issues raised in this section on the economic approach to index numbers.
10. See Elliott, O'Neill, and Winton (2013), Levell (2015) and Johnson (2015) for more information on recent developments in this discussion in the UK context.

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