Estimating Commodity Substitution Bias in the Irish Inflation Rate Statistics during the Financial Crisis

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Abstract: Measures such as the Consumer Price Index are important economic indicators setting out price changes in the Irish economy over time. Such measures, however, are subject to various types of measurement bias. The latter can include Commodity Substitution Bias whereby the weights assigned to each item in a representative basket of goods and services cease to fully reflect consumer expenditure patterns over time, and particularly during a period of economic upheaval. This, in turn, can lead to the overstatement (or understatement) of inflation. The Central Statistics Office (CSO) now updates the relevant weights every year, thereby reducing the impact of this bias. In this article, we have endeavoured to estimate the size of the bias in the period leading up to the introduction of the new methodology in 2012. The results presented here indicate that the rate of inflation was slightly understated. The degree of this measurement bias was not significantly higher than that identified in other countries in which this phenomenon has been examined, albeit that in the latter countries an upward bias (or overstatement) was found.

I INTRODUCTION

The recent global financial crisis led to a fall in output and rising unemployment in Ireland accompanied by significant price changes. This deflation has been unusual by historical domestic and international standards.

The deflation experienced in Ireland was of a greater magnitude than in other European countries that have experienced financial difficulties and rather than returning to inflation quickly, Irish deflation lasted for 22 consecutive months (Bermingham *et al.*, 2012). Measures such as the Consumer Price Index (CPI) and the Harmonised Index of Consumer Prices[1] (HICP) are important economic indicators setting out price changes in the Irish economy over time. These measures are also used as a means of benchmarking (or setting) changes in remuneration, pensions, social welfare payments and other contracts (Central Statistics Office, 2012a). These measures are pure price indices and measure the change in the level of prices of consumer goods and services. These do not purport to be cost of living indices. It is important that these indices be as accurate a measure of Irish inflation as possible.

Such measures, however, are subject to various types of measurement bias. These include Commodity Substitution Bias. This arises due to the use of an imperfect indexing formula (Rossiter, 2005). Such a formula does not capture changes in consumer behaviour[2] as a fixed basket of goods and services with weights updated every five years has, until very recently, been used. This can lead to the overstatement (or understatement) of inflation. Such behavioural changes are particularly likely during periods of economic downturn as consumers move away from, or towards, certain types of products. The fact that annual weightings are not available for the period 2006 to 2011 imposes some important constraints on the authors. Moreover, there are also other types of bias – such as quality change and new goods – that can further impact upon the measurement of prices. These issues are discussed further below.

This paper is structured as follows: Section II outlines a range of potential sources of bias; Section III outlines the manner in which price indices are used to measure average price changes in Ireland over time and the potential for a series of measurement biases to skew these inflation rates whilst the methodology underpinning the calculation of the Commodity Substitution Bias is presented in Section IV; Section V sets out the results of this exercise; and Section VI concludes.

II LITERATURE REVIEW

2.1 *Potential Sources of Bias*

Commodity substitution bias is one of the main sources of bias in the measurement of inflation and it is also one of the most easily quantifiable (Crawford, 1998; Lebow and Rudd, 2003; Rossiter, 2005). In addition to

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[1] The HICP is, effectively, a subset of the main CPI.
[2] Where these changes take place following the periodic re-basing of the index.

commodity substitution bias, there are three further principal sources of bias: (1) outlet substitution bias, (2) quality change bias, and (3) new goods bias (Rossiter, 2005). Outlet substitution bias relates to changes in the retail landscape. As in many countries, the Irish retail industry has changed significantly over the past decade with the emergence of new industry players and in particular, the growth of discount retailers. This can result in a positive (or upward) bias when discount retailers offer lower prices, relative to their older competitors, but where these lower prices are not picked up in the price index.

Quality change bias arises due to the use of inappropriate quality adjustment techniques. There are a number of standard adjustment methods to, at least partially, resolve this bias but these can still inaccurately measure quality changes. This results in a positive bias where actual quality improvements occur faster than they can be measured. New goods bias relates to the belated treatment of new products and brands. Where a price index cannot capture the impact upon consumer welfare of the introduction of new goods and services, this can result in a positive bias. This consists of both new product bias and new brands bias.

The former relates to changes in consumer behaviour as new goods enter the marketplace but where such goods are not yet included in the CPI basket. As prices of new goods and services generally decrease after their introduction, this results in a positive bias. The latter relates to enhanced consumer welfare due to greater brand choice. A positive bias arises where the CPI fails to take account of this welfare gain where consumers value new brands more than their extant counterparts. It is conceivable that these additional biases could be greater than the rate of commodity substitution bias estimated here. For the purposes of this article, however, the authors are only estimating commodity substitution bias but there is scope for further fruitful research in this area.

2.2 *Commodity Substitution Bias: International Comparators*

International estimates have indicated that the contribution of commodity substitution bias to annual measured inflation can and does vary widely. The estimated bias in the UK, France and Germany was quite modest at up to 0.1 per cent per annum. This compared to 0.15 per cent per annum and 0.35 per cent per annum in some more recent estimates for Canada and the United States, respectively (see Table 1).

In those studies, it was found that an upward bias was present with inflation being overstated during the 1990s and into the mid-2000s. It must be borne in mind, however, that the bias in the Irish inflation statistics estimated here occurred against a background of changing economic fundamentals which shaped both consumer behaviour and the representative basket of goods and services.

Table 1: *International Estimates of Measurement Bias*

Country	Year of Study	Commodity Substitution Bias %	Total Bias
UK	1996	0.05-0.10	0.35-0.80
Germany	1998	0.10	0.75
France	1997	0.05-0.10	n/a
US	2003	0.35	0.87
Canada	2005	0.15	0.58

Source: Rossiter (2005).

III MEASURING THE IRISH INFLATION RATE

3.1 *Measuring Average Inflation*

Changes in the price of goods purchased by consumers are measured using price indices, including the CPI and the HICP. These indices measure the average change in the price of goods and services[3] over time. Such measurements reflect an average measure of the change in prices using a single figure that combines all of the price changes covered. These measurements are based on a shopping basket "comprising a fixed set of goods and services bought by a typical private households (Laspeyres index formula)" (Central Statistics Office, 2012b).[4] The quantity of each item in this basket is proportionate to the average amount purchased by each private household. The latter was previously determined using the Household Budget Survey (HBS) so that each item in the basket is allocated a specific weighting.[5] These weightings were previously revised every five years in line with changing expenditure patterns.

The Irish inflation rate is measured using a chained Laspeyres price index, as required under EU legislation. This index measures changes in the cost of consumer goods and services (inclusive of indirect taxes). The basket of goods and services is fixed between updates.[6] A Laspeyres index, however, will in theory contain an in-built upward bias as consumers will generally change their consumption behaviour over time away from higher inflation items. The inverse will tend to apply, on the other hand, to a Paasche index (Everts, 2013).

[3] Bought for the purpose of consumption by all private households in the country and by tourists on holiday in the country.
[4] As the prices of individual items in this basket change, the total cost of the basket will change.
[5] The base is periodically re-set at 100 using weightings derived from the most recent HBS; each item in the basket is assigned a weighting where all items sum to 10,000.
[6] The basket of goods and services used, and the associated index weights, are updated periodically in order to ensure that they are representative of current expenditure patterns. Eleven different weighting bases have been used between 1922 and 2011 with seven covering the period since the introduction of the first index (with base: July 1914) in March 1922 up to the introduction of the seventh (with base: November 1989) in February 1990. Since 1996, major updates (or rebases) have been undertaken on a five-yearly cycle (1996, 2001, 2006 and 2011).

The CPI – and the HICP – is a pure price index. These are not cost of living indices. A cost of living index includes items such as income levels, taxation, social welfare payments and substitution between dearer and cheaper goods and is more difficult to construct (Central Statistics Office, 2014a). The CPI does, however, measure the change in price levels – one of the principal determinants of the change in the cost of living – albeit that this is all that the CPI is intended to measure.

3.2 *Commodity Substitution Bias*

This bias is due to the use of a Laspeyres price index to calculate the inflation rate. In other words, the weights attached to each item in a basket of goods or services can change, as consumer consumption patterns change, and these changes can influence the measured rate of inflation. As the basket used to calculate the inflation rate was, prior to 2012, only updated every five years, the weights used remained unchanged. Substitution by consumers between goods can lead to an overstatement of the inflation rate. For example, consumers might substitute away from beef and towards chicken were the price of beef to increase significantly between basket updates (or also, perhaps, due to falling household disposable income). The weight attached to beef in the Laspeyres price index would, however, remain unchanged until the next update (Rossiter, 2005). This would lead to an overstatement of price changes due to the changing composition of household expenditure.

Where there is a negative correlation between quantity (weighted by values) and price changes, then the Laspeyres index would be expected to exceed the Paasche index. Given that consumers are generally price-takers, they tend to substitute away from goods and services that have become relatively more expensive. However, where these price and quantity changes are positively correlated, the Paasche index would exceed the Laspeyres index (Everts, 2013).

In Ireland's case, the weights allocated to a variety of Unprocessed Foods, including roast beef and salmon, in the 2006 CPI basket were subsequently re-set downwards in 2011 (reflecting average consumer consumption moving away from these items). These weightings, however, can also be revised upwards. This implies that it is also possible to understate inflation. For instance, the weights for items such as chicken and various Processed Foods were increased over this period. Moreover, the weights for Energy, including electricity and natural gas, were revised substantially upwards.

The CPI weights were used for the purposes of the analysis presented here. A summary of the change in these weightings under 11 broad expenditure categories is presented in Table 2 below.

Table 2: *CPI Basket Weights, 2006 and 2011*

Category	2006	2011
	Weight (%)	
Energy	7.76	11.36
Processed Food	6.50	6.89
Unprocessed Food	4.96	4.68
Alcohol and Tobacco	6.05	4.91
Core Services*	34.68	32.68
Administered Services**	4.47	8.10
Alcohol-related Services***	7.44	6.49
Telecom Services	3.34	3.39
Non-Energy Industrial Goods****	18.55	15.37
Clothing and Footwear	5.25	5.11
Other	1.00	1.22

*Includes shelter (mortgage interest and private rents).
**Includes local authority rents, refuse collection, passport fees, etc. The authors re-allocated a number of items from Core Services to Administered Services in 2011 in order to undertake a direct comparison.
***Refers to licensed premises.
****Includes household furnishings & operations and health & personal care.
Note: Some sub-totals have been rounded. The above includes all items in the CPI basket at each point in time.

3.3 *Data Constraints and Assumptions*

When examining issues such as commodity substitution bias, annual weights are typically used. Prior to 2012, however, annual weights are not available. In the absence of this annual step change data, it was not feasible to calculate robust estimates for this bias in each individual year using the geometric mean between both indices. In order to do so, we would be required to assume that the weights have changed on a constant basis between 2006 and 2011 in order to approximate Paasche and Fisher indices in each year for comparative purposes. It is possible that the weights for a given item could have changed at a different rate year-on-year (rather than at a constant rate). The authors did, however, endeavour to produce estimates of the annual bias using an empirical approach (rather than an assumptions-based approach), albeit that these results are not directly comparable to the results for both indices in each year. This is discussed further below.

IV CALCULATING COMMODITY SUBSTITUTION BIAS

For the purposes of measuring price changes, a Laspeyres index tracks price changes for a given basket of goods and services. The observed price changes

over time for each item are weighted with reference to the proportionate contribution of that item to the basket at the start of the period (in this case, 2006). In the case of a Paasche index, more recent weights are assigned to each item, thereby better reflecting any changes in consumer behaviour over time, such as changing tastes.

Laspeyres (P_t^L) price index (1), used for both the CPI and HICP, holds quantities constant at the base period level where $Q_{t,j}$ is the quantity of good or service j consumed at period t and $P_{t,j}$ is the price of good or service j at period t. By contrast, the Paasche (P_t^P) price index (2) uses current period quantities.[7]

$$P_t^L = \frac{\sum_{j=1}^{N} Q_{0,j} \ P_{t,j}}{\sum_{j=1}^{N} Q_{0,j} \ P_{0,j}} \tag{1}$$

$$P_t^P = \frac{\sum_{j=1}^{N} Q_{t,j} \ P_{t,j}}{\sum_{j=1}^{N} Q_{t,j} \ P_{0,j}} \tag{2}$$

Commodity substitution bias can be measured using Fisher's "ideal" price index (P_t^F) which accounts for quantity changes. This measure is a geometric mean of the Laspeyres (P_t^L) and Paasche (P_t^P) indexes. This approach can help to overcome the problems associated with commodity substitution bias as it more accurately measures price changes as consumption patterns change. The result for the Laspeyres index will normally exceed the Fisher index whilst the result for the Fisher index will normally exceed the Paasche index (Rossiter, 2005; Everts, 2013).

$$P_t^F = \sqrt{P_t^L \, P_t^P} \tag{3}$$

In order to calculate the results presented here, the authors compared the cumulative weightings on a month-by-month basis and used the latter to calculate an annual average for each index covering the years 2008 through 2011. For instance, we compared the applicable weightings for each month in 2008 with the corresponding months in 2007 and used these results to calculate the annual average inflation rate for 2008. In the case of the Paasche index, we used the December 2011 weightings and used these to re-estimate the weightings for each month commencing January 2007 onwards by applying the

[7] Refers to December 2011.

observed monthly price changes for each individual item in the basket used here.

4.1 *Treatment of Inter-period Changes to the CPI Basket*

Before we could produce these estimates, however, it was necessary to construct a chained index for a common basket of goods and services across both periods.[8] The basket of goods and services is periodically re-based and updated so that no two baskets are exactly identical. Pursuant to a review of the coverage of goods and services in 2011, a comprehensive update was undertaken by the CSO. The consequent changes to the basket of goods and services included replacements,[9] additions and deletions. Furthermore, a number of modifications, combinations and splits were also introduced whilst a small number of items were renamed. In the 2006 base index, there were 616 item headings but by 2011, this had increased to 632 item headings.

In order to arrive at a two directly comparable baskets of goods and services, it was necessary to identify and resolve inter-period differences. For example, items that were not included in the 2011 basket were also excluded from the 2006 basket. Where items were only introduced from 2011, these were also excluded in the analysis.[10] These changes yielded a common set of 584 items at both points in time.

4.2 *Using an Internationally Comparable Measure*

Finally, the estimates of commodity substitution bias were produced using the HICP basket of goods and services by means of removing a small number of further items from the CPI basket. This HICP measure was developed by EU countries to improve cross-country inflation comparisons as problems can arise as a result of definitional and methodological variations between countries (particularly with regard to the treatment of housing costs). Consequently, the HICP is generally used to compare Irish inflation with that of other countries. To this end, a further eight items which are deemed to be outside of the scope of the HICP coverage[11] were excluded from the CPI basket of goods and services (Central Statistics Office, 2012c). This yielded a final common set of 576 items.

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[8] Refers to the 2006 and 2011 updates to the CPI basket.

[9] A product has been directly substituted by a corresponding product or has been replaced by a different item.

[10] In the case of replacements, the 2006 and 2011 items were both retained. The authors recognise that excluding these "deletions" (i.e. cauliflower, DVD hire, etc.) and "additions" (i.e. memory sticks, music downloads, etc.) will inevitably impact the results presented here. Given that the basket of goods and services in 2006 and 2011 was selected to be representative of the expenditure of an average household in those years, the sampling is potentially compromised by these changes. Nonetheless, a consistent sample was necessary for the analyses undertaken.

[11] Mortgage interest, building materials, motor tax (motor cycle), motor tax (car), house insurance (contents; non-service), home insurance (dwelling), motor car insurance (non-service) and union subscriptions.

V ESTIMATES OF COMMODITY SUBSTITUTION BIAS

The estimates presented here indicate that the HICP, a Laspeyres price index, led to Irish inflation rate being understated over the period 2006 to 2011 by approximately 1.4 per cent (in cumulative terms),[12] using a common set of items from the 2006 and 2011 baskets. This differential arises because the current period (2011) quantities (or weightings) for some items in this basket are slightly higher than for the base period (2006). This means that the latter leads to a slightly lower estimated inflation rate in many cases.

Table 3: *Comparing Estimated Index Results, 2008 to 2011**

Year	Inflation Laspeyres Price Index %	Inflation Paasche Price Index	Fisher Index	Estimated Bias
2008	3.1	3.8	3.5	2.5
2009	−1.6	−2.1	−1.8	−3.0
2010	−1.4	−0.2	−0.8	0.5
2011	1.5	3.1	2.3	−1.4
Cumulative	1.7	4.6	3.1	−1.4

*Based upon a common inter-period basket of 576 items (and not the full fixed basket referred to in CSO publications).
Notes:
1. Results based on annual averages.
2. The estimated bias is the geometric mean of both indices and this was used to calculate the Fisher Index result in each year and to derive the cumulative bias result.
3. The further estimates for an annual bias in each year from 2008 to 2011 were produced separately using an amended methodology which is not directly comparable to the other results shown here. These amendments were based upon Table 14 of the National Income and Expenditure (NIE) data.

The dynamic underpinning this headline result, however, will have varied year-on-year rather than being smooth over the period. In order to estimate an annual bias, the authors amended the primary methodology – and weights – using National Income and Expenditure data[13] which give an indication of expenditure and the consumption of personal income.

5.1 *Principal Contributions by Expenditure Category*
A small number of expenditure categories played an important role in driving these results. Energy prices increased quite substantially between 2006

[12] Calculated using annual averages.
[13] These amendments give rise to a different Fisher Index result in each year than is shown in Table 3 above.

and 2011. The 2006 weightings attached to these items, however, did not reflect changing consumption patterns. In effect, the original weights were correct for the Laspeyres index but they did lead to commodity substitution bias due to the changes in the proportion of household income spent on certain items. The weights for Energy, for instance, were increased by 46 per cent with the December 2011 re-basing exercise. This implies that consumers increasingly spent more of their income on energy due to an absence of substitutes. Inflation in energy prices over this period was not fully captured in the published inflation statistics.

Similarly, the price of Administered Services[14] also increased significantly after 2006. The relevant weightings were increased by 34 per cent with the December 2011 re-basing exercise and, as such, the inflation in the prices of these services was also not fully captured. Finally, estimates of commodity substitution bias using the full CPI basket of items produced broadly similar results at the headline level.

VI CONCLUSIONS

Standard measures of inflation are important economic indicators setting out price changes in the Irish economy over time. It is important that these indices be as accurate a measure of Irish inflation as possible as these measures are regularly used as a means of benchmarking (or setting) changes in remuneration, pensions, social welfare payments and other contracts. Such measures, however, are subject to various types of measurement bias, including Commodity Substitution Bias. This can arise because expenditure weights are fixed between rebases. When prices are changing quickly, however, consumers will tend to buy goods and services which have falling relative prices.

These changes in expenditure patterns are not detected until the next rebase (with the next full rebase due in 2017).[15] Since 2012, the CPI (and HICP) weights are now updated annually, thereby addressing this issue. The objective of this paper is to estimate the size of this bias in the period leading up to the introduction of the new methodology. In the Irish case, it would appear that this commodity substitution bias led to inflation being understated over the period 2006 to 2011.

This bias was particularly driven by consumers spending more of their disposable household income on certain core items such as energy and shelter, in addition to changing relative prices. For instance, Energy prices rose by

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[14] Includes a range of items including public transport fares, refuse charges, tolls and local authority rents; a number of these items were classified as "Services" in 2011 but the authors re-classified these as Administered Services for comparative purposes.

[15] December 2016 = 100.

approximately 30 per cent between 2006 and 2011[16] but the weightings attached to these items actually increased substantially over the same period. In other words, price and quantity changes were positively correlated. A similar trend was observed for other items, including Processed Food. By contrast, for items such as Core Services[17] both price and quantity changes were relatively flat.

Under the revised procedure, National Accounts data are used in the annual updating of the (sub-index) weights.[18] This methodological improvement means that these measures have "become a truly chained Laspeyres-type price index" (Central Statistics Office, 2014). This will reduce the scope for Commodity Substitution Bias in the official inflation rate statistics as the various sub-index weights will approximate as close as possible the consumers' expenditure pattern of the previous calendar year.

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[16] According to the CSO StatBank (CPM03: Consumer Price Index by selected sub-indices, month and statistic).

[17] In the case of the consistent basket of goods and services used in this analysis (excluding mortgage interest), these weightings were effectively unchanged.

[18] In line with Commission Regulation (EU) No 1114/2010 on minimum standards for the quality of Harmonised Indices of Consumer Prices (effective 2012).