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Abstract

This paper develops what is believed to be a novel method of resurrecting UK national accounts corporate sector data before 1987, the date prior to which fully comprehensive sectoral data are not provided by the Office for National Statistics. A distinction is drawn between the sectors comprising private non-financial corporations (PNFC), on the one hand, and financial corporations, which include some state-controlled enterprises, on the other hand. The resurrected PNFC dataset runs in detail from 1960. A much more limited set of reconstructed data is available for financial corporations. The resurrected data include the savings – broadly speaking, the "retained profits" – and the financial balances – the difference between retained profits and capital spending – of both corporate sectors.

Economists collaborating with the UK Economic Statistics Centre of Excellence describe an exercise of this kind as "especially difficult". My method of reconstruction relies on archived, out-of-date, too frequently unreliable national accounts datasets, the scrutiny of those data to remove mistakes, and a detailed examination of a subset of an otherwise overwhelming number of national accounts revisions confined to those having a material and enduring impact in the historic period before 1987.

This "bottom-up" method of data reconstruction differs from the "top-down" method of resurrecting the accounts of the public, the rest-of-the-world and the "private" sectors, and the separation of the household sector from the aggregate corporate sector, described in a previous paper: Martin (2019). The combination of the two methods, one bottom-up, the other largely top-down, risks the creation of a dustbin into which data inconsistencies are unwittingly poured. A number of robustness tests provides reassurance that the differently derived historic data for sectoral saving make sense. Comparable tests of household and corporate sectors' financial balance data are not possible, but the hypothesis that different vintages of PNFC financial balance data are isomorphic representations of the same economic variable is not rejected. The combination of the two methods has allowed improvements to be made to the resurrected household sector series that begin in 1946.

Subject to the resolution of outstanding problems with official national accounts data, notably for gross fixed capital formation before 1960, and additional scrutiny and comment, it is the intention to make the complete resurrected sectoral dataset publicly available.

Keywords: national accounts, private non-financial corporations, macroeconomics, UK statistics.

JEL Codes: C82, E01, N1.

Resurrecting the UK corporate sector accounts

Is it legitimate to combine obsolete data with the latest official statistics to study the economic history of the UK's private corporations? The question arises because the official statistics agency, the Office for National Statistics (ONS), does not provide a fully functional dataset for the private corporate sector before 1987. There is nothing, for example, on UK corporates' retained profits or their capital spending; nor, therefore, on the gap between the two: corporates' financial balance. For such information, one has currently to turn to archived official datasets, which are out of date, often corrupted and, in many respects, incompatible with the latest official data that exist only from 1987.

The absence of a reliable long-run dataset is a high hurdle facing researchers, and not only those who seek to understand recent puzzling corporate behaviour in an historical context. The missing history of corporate data is just one aspect of a general weakness of the official national sector accounts. In principle, these offer a system of accounting relationships that quantify the income, spending and financial balances (or "net lending") of all "institutional" national sectors, including government and households as well as companies. One of the great attractions of this accounting system is its coherence: it aids understanding of the behaviour of individual sectors seen not just in isolation from one another but as part of an interrelated whole. The weakness of the UK national sector accounts is that their economy-wide coherence is confined to the period since 1987.

This statistical hole is the direct result of the conversion of the national accounts in 1998 to the then new – and, for European Member States, mandatory – accounting standard, usually referred to as the 1995 European System of Accounts (ESA95). The ONS delivered a "core" ESA95 dataset for the main national accounts, including the gross domestic product, stretching back to 1948. But to comply with a minimum requirement for past data, the hard-pressed statisticians chose the year 1987 as the starting date for the full set of sector accounts. At that time, the ONS usefully provided some less-than-comprehensive sector data before 1987, but many of these series later became corrupted and all were subsequently removed. Despite the current ONS "transformation" programme, and major, collaborative efforts to resurrect historic data under the auspices of the Economic Statistics Centre of Excellence (ESCoE), the same data gap exists today, only under the latest accounting standard, ESA10, introduced in 2014. From the perspective of historical continuity, the UK national sector accounts have regressed. Before the 1998 conversion to ESA95, the national accounts followed a variety of (non-mandatory) best practice international accounting standards. "Pre-ESA95" sector data went back as far as 1946.

Some repair of the historic sector record before 1987 is possible. By combining a number of official sources, one can backcast historical data for the major institutional sectors: public (general government and public corporations),

overseas (the "rest of the world") and the residual "private sector". My 2009 and 2019 papers detail the methodology under, respectively, ESA95 and ESA10 accounting standards, the later paper extending the method to separate before 1987 the household sector from the aggregate corporate sector.

Regrettably, the same methodology cannot be used to derive historic data for two main parts of the corporate sector: one comprising private non-financial corporations (PNFC), the other comprising financial corporations. For these two sub-groups, a different approach is required.

The one adopted here starts with archived national accounts data that are out-of-date and conform to discontinued accounting standards. This approach faces several problems, not least how one might best refashion old data to new concepts. There is also the challenge of ensuring consistency. The two methods of backcasting – one based on the methods explained in Martin (2019) and the other based on archived records - are materially different. Will the numbers backcast for private corporations using rival methods add up? To answer this question, a number of tests of data robustness have to be considered. It is concluded that a PNFC dataset and a more limited set of data for financial corporations can be resurrected in a way that makes sense back to 1960.

This paper begins with a summary and update of the method used to backcast aggregate sector data. Attention then turns to the available archived sources of historic data on PNFC and financial corporations, to the selection of the most reliable source, and to the adjustments required to resurrect historic corporate data that conform to modern standards.

1) Resurrecting historic aggregate sector data: summary and update

The method by which institutional sector data consistent with ESA10 are derivable before 1987 brings together ONS data available in three related, but differently presented, official datasets: (i) the national accounts, (ii) the version of the public sector finances analytical tables (PSAT) that attempts to be consistent with the national accounts, and (iii) the balance of payments accounts, which conform to a different international standard (the sixth edition of the International Monetary Fund's Balance of Payments Manual, BPM6) but one that is also consistent with ESA10. Sector data before 1987 can be derived in the most detail for a number of broad aggregates: general government, public (non-financial) corporations, and the "rest-of the-world". The remaining aggregate sector is typically referred to as the "private sector", although it should be borne in mind that it includes government-controlled financial corporations, such as nationalised banks. Data for the private sector can be inferred, with series extending back to 1948, and, after some rough estimation, to 1946.

The method of inference is crystallised in the across-sector financial balance (F) identity (1):

$$F_v \equiv -\left(F_u + F_w + ERR \right) \tag{1}$$

Here the main sectors - private, "public" (the sectors comprising general government and non-financial public corporations) and the rest-of-the-world – are denoted with subscripts "v", "u" and "w", respectively. *ERR* denotes the national accounts residual error, which, by convention, records the excess of the gross domestic product (GDP) derived using expenditure data, GDP(E), over that derived using income data, GDP(I). Official ESA10 data exist for the public, F_u, and overseas, F_w, financial balances from 1946 and for the residual error from 1948. The backcasting of the residual error for two years is in principle the only estimation required to derive the private sector financial balance from 1946. Additional minor estimation is required to backcast related series for private sector disposable income, saving and for some of the items – capital taxes, net other capital transfers and gross capital formation - on capital ("accumulation") account. In practice, the derivation of historic series for disposable income, expenditure and other capital account items provides an essential check on the integrity of the financial balance estimates derived using identity (1).

Martin (2019) also presents backcast estimates for the private sector's constituent sectors: households (defined to include non-profit institutions serving households, such as charities and universities) and private corporations. This spilt, the major innovation in Martin (2019), relies on an official ONS series for household saving that begins in 1963, and which can be backcast to earlier years once allowance is made for pension saving. The deduction of estimates of household saving from private sector saving before 1987 provides an historic series for private corporate saving (broadly speaking, corporates' undistributed profits). To backcast the financial balances of households and corporations, use is also made of suitably adapted pre-ESA95 data on capital transfers and capital formation.

Qualifying these backcast estimates are weaknesses in the official data. There is an absence of clear documentation regarding the provenance of the official pre-1987 household saving data, which were updated by a linking process during the ESA10 conversion (Davies et al., 2015). Martin (2019) also draws attention to (1) the tendency of the ONS to truncate data revisions at arbitrary dates (1987 and 1997), giving rise to artificial jumps in levels and growth rates ("cliff-edges") in some time series and to inconsistencies before 1987 between two series that feature in both the national accounts and the "national accounts consistent" public sector analytical tables; to (2) the suspected understatement of historic estimates of gross fixed capital formation and GDP in years before 1960; and to (3) concerns about early-post second world war data for overseas and domestic

capital transfers. These matters were raised with the ONS in the first half of 2019. As of this writing the ONS has accepted that the large downward revisions before 1960 to gross fixed capital formation that were made in the 2014 Blue Book are counterintuitive, and plans to adjust the affected data. There has been no resolution of the other matters that affect the national accounts consistent PSAT before 1987 and, less certainly, the record of capital transfers before 1954.

Also qualifying the backcast household and corporate sector estimates are the techniques chosen in Martin (2019) to backcast the sectors' gross fixed capital formation. Spliced pre-ESA95 data were used to form proxies for household and private corporate gross fixed capital formation with each series scaled to align their total with the backcast private sector aggregate. It is not possible independently to test the reliability of this crude mechanical method, which takes no account of wider considerations, including the balancing of the expenditure and income measures of GDP. This weakness is partly addressed here by developing a new backcast series for PNFC gross fixed capital formation that confines the deployment of pre-ESA95 data and mechanical methods to the backcasting of the gross fixed capital formation of households and financial corporations.

A presentational change is also made to handle, but not resolve, the data inconsistencies before 1987 between the national accounts core dataset and the national accounts consistent PSAT. Despite their name, these PSAT do not, as of this writing, correctly replicate before 1987 two series included in the core national accounts: general government current expenditure on goods and services and the general government gross operating surplus (capital consumption). The two series are components not only of the public sector finances accounts but also of the expenditure and income measures of GDP. Retention of the national accounts series is required to satisfy key national accounting identities but comes at the expense of creating departures from the public sector finances record before 1987.

One solution, adopted in Martin (2019), is to recalculate the public sector balances before 1987 in line with the national accounts series for government current expenditure and gross operating surplus. But while protecting the national accounting, this solution has the disadvantage of making more difficult comparison with estimates that use the "headline" public sector finances series for government saving and the financial balance. To aid such comparison, the alternative solution, adopted here, uses before 1987 the headline series that appear in the public sector finances analytical tables which do not purport to be consistent with the national accounts ("regular PSAT"). This solution has the added advantage of addressing a technical complication that arose from the method used by the ONS in May 2019 to correct the regular PSAT historical record of UK contributions to the European Union.

The new solution can however be no more than presentational; it does not resolve the underlying discrepancy between the national accounts and the purportedly national accounts consistent PSAT statistics. The imposition of otherwise inconsistent government saving and financial balance data before 1987 requires resort to a residual "dustbin" item elsewhere in the accounting. This residual is now arbitrarily allocated to general government current transfers, a series judged to be of less intrinsic interest to macroeconomists than the headline public sector finances series. The underlying problem of dataset inconsistency awaits resolution by the ONS.

The Martin (2019) backcasting methodology cannot be extended to distinguish before 1987 between the sector accounts of the two major corporate sub-sectors: PNFC, formerly known as industrial and commercial companies (ICC), and financial corporations, a broad church of corporate enterprises involved in various forms of financial intermediation. Today's official private corporate sector data before 1987 are confined to series for corporates' gross operating surplus, data which extend back to 1948. To backcast PNFC sector accounts before 1987, and, by implication, data for financial corporations as a whole, a different backcasting methodology has to be deployed, one that relies here on archived national sector accounts data. The following sections describe the main sources of archived private corporate sector data, the nature and scale of national accounts revisions, the backcasting method, and the tests required to assess reliability.

2) Archived private corporate sector data before 1987

Primary sources of UK national accounts corporate sector data before 1987 can be divided into two broad groups: (i) Pre-ESA95 and (ii) Early-ESA95. The pre-ESA95 data were last published in the 1997 *United Kingdom National Accounts* (the "Blue Book") and in the early-1998 publication *UK Economic Accounts,* which extended the dataset by one year to include 1997. As described in Sefton and Weale (1995, chapters 6 and 7), the pre-ESA95 dataset is far from error-free, but aided by those authors' careful methods it can be corrected to meet the requirements of the present paper.

The early-ESA95 datasets comprise the vintages of ESA95 data published first in the 1998 Blue Book, then in the comprehensive revision in the 2001 Blue Book, and, until early-2007, in subsequent Blue Books and the quarterly editions of *UK Economic Accounts*. Unfortunately, database management errors led to the widespread corruption of the data before 1987. The problems are detailed in Martin (2007 and 2009). Examples of data corruption included missing observations within otherwise continuous time series and the overwriting of data, with one series masquerading as another. As the historic sector accounts were not properly integrated, data before 1987 could be, and were, revised by different statistical branches of the ONS in an uncoordinated fashion. The result was incoherence. The then official statistics watchdog concluded that there was a

substantial number of historic time series which were "not fit for use in analysis" (Statistics Commission, 2007). During the course of 2007, the ONS purged rather than repaired most of the corrupted data and expunged any remaining series in 2011. It follows that the selection of archived early-ESA95 data for the purposes here must take very careful note of data corruption and identity breaches.

The choice of archived data is considered in detail in Annex A. Selection criteria include the time span of the available data, the accounting standard used, and the integrity of the data: do they add up? As a result of this review, the 2001 Blue Book dataset, with certain important corrections, is chosen as the preferred historic source for the PNFC sector accounts. The main dataset begins in 1960. The pre-ESA95 dataset is rejected because it fails closely to replicate in the historic period before 1987 the latest vintage data for the private sector financial balance, of which the PNFC financial balance should be a sub-set. Additional considerations are as follows:

1) Compared with the pre-ESA95 accounts, the ESA95 accounts incorporate two important innovations: first, the recategorisation of partnerships from the former personal sector to the corporate sector and, second, the inclusion for the first time of a number of intangibles, notably computer software, within the definition of gross fixed capital formation. The non-negligible impact of these innovations is documented in Dolling (1998). Amongst many other changes, ESA95 also redefined the concept of rent income and identified insurance corporations and pension funds as a sub-sector within the financial corporations sector.

2) Compared with the first published ESA95 set of accounts, the 2001 Blue Book addresses a number of deficiencies, including an overstatement of partnerships' mixed income.

3) The 2001 Blue Book data satisfy the PNFC sector specific accounting identities, save for a miscalculation of the financial balance before 1987.

Two corrections must be applied to the 2001 Blue Book PNFC data. The error noted at point (3) is addressed by bringing the historic financial balance data before 1987 into conformity with the 2001 Blue Book data on saving and other capital account items. The second adjustment is to the record of PNFC gross operating surplus before 1963. These data were subsequently amended by the ONS to address discrepancies which had led to a large misstatement in the 2001 Blue Book of GDP(I) relative to GDP(E). The resulting upward revisions to PNFC gross operating surplus in the 1960 to 1962 interval, and the impact on saving and the financial balance, are incorporated in the corrected 2001 Blue Book PNFC accounts used here.

An equivalent dataset does not exist for financial corporations. It follows that the resurrection of the financial corporations sector data can only be achieved by residual: by subtracting the resurrected PNFC data from the resurrected private corporate sector data. The latter are themselves derived residually, by subtracting the resurrected household sector data from the aggregate private sector data. This sequence of calculations explains the importance of selecting an archived dataset that shows the closest conformity with the latest vintage estimates for the private sector as a whole. This criterion rules out the pre-ESA95 dataset, despite its usefulness in other contexts, but still leaves open the possibility that the sequence of calculations drawing on ESA95 data will fail to make sense. A later section explores this key question in detail, and gives an answer that offers reassurance.

3) Resurrecting the PNFC sector accounts

(i) Identifying material revisions

Attention now turns to the PNFC accounts, starting with a comparison of the 2001 Blue Book data with those consistent with the 2019 Blue Book: as of this writing, the latest available. The purpose of the comparison is to ascertain whether the archived ESA95 data might be used unchanged to backcast PNFC data before 1987, and, if not, which series require adjustment. This preliminary examination is a precursor to an analysis of the properties of revisions and how these can be best incorporated to bring the archived dataset into conformity with modern measurement standards.

Table 1 summarises the differences between the 2019 Blue Book data and the 2001 Blue Book data for a selection of major PNFC series from 1987. Each series revision is calculated as a per cent share of latest vintage GDP. For some purposes, it should be acknowledged that it would be better to use the vintage of GDP appropriate to the dataset under consideration. However, use here of the latest estimate of GDP has the advantage, apart from computational simplicity, of bringing out directly the revisions in the levels of each series. The revisions are recorded for both a single year, 1987, and for the average of the 14 annual observations during the overlapping interval from 1987 to the year 2000.
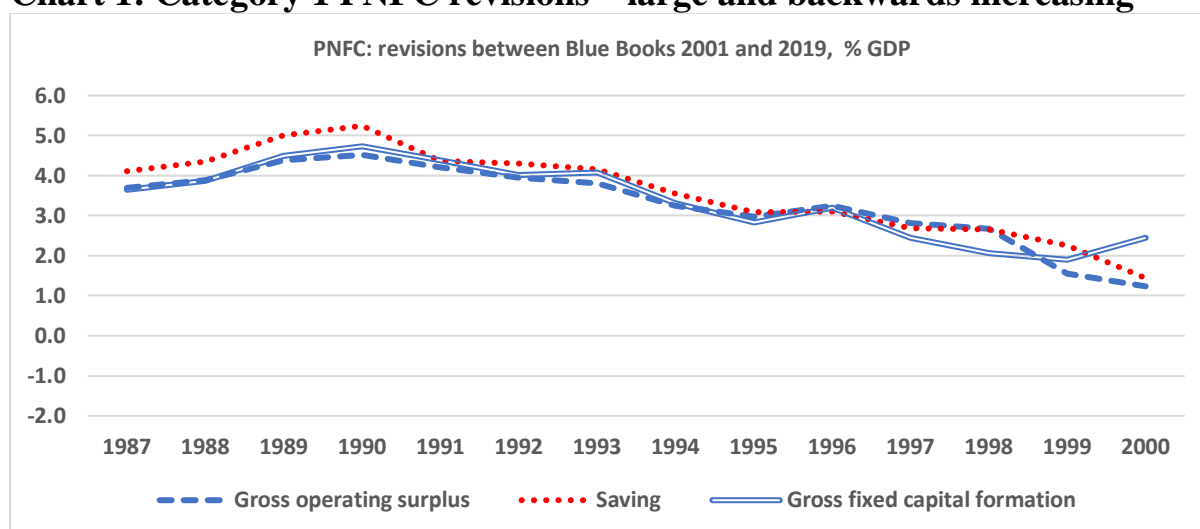
Two striking features of these results are, first, the very large revisions to a number of key series (gross operating surplus, saving and gross fixed capital formation) in contrast to the much smaller revision recorded for the financial balance, and, second, the fact that the revisions for a number of series – again, gross operating surplus, saving, gross fixed capital formation, the financial balance, and, additionally, net interest property income and net other current transfers – do not diminish with the passage of time. It is noticeable that the revisions to these series recorded for 1987 are at least as large as the averages of the revisions to these series over the full overlapping period.

Table 1: PNFC data revisions between 2001 Blue Book and 2019 Blue Book

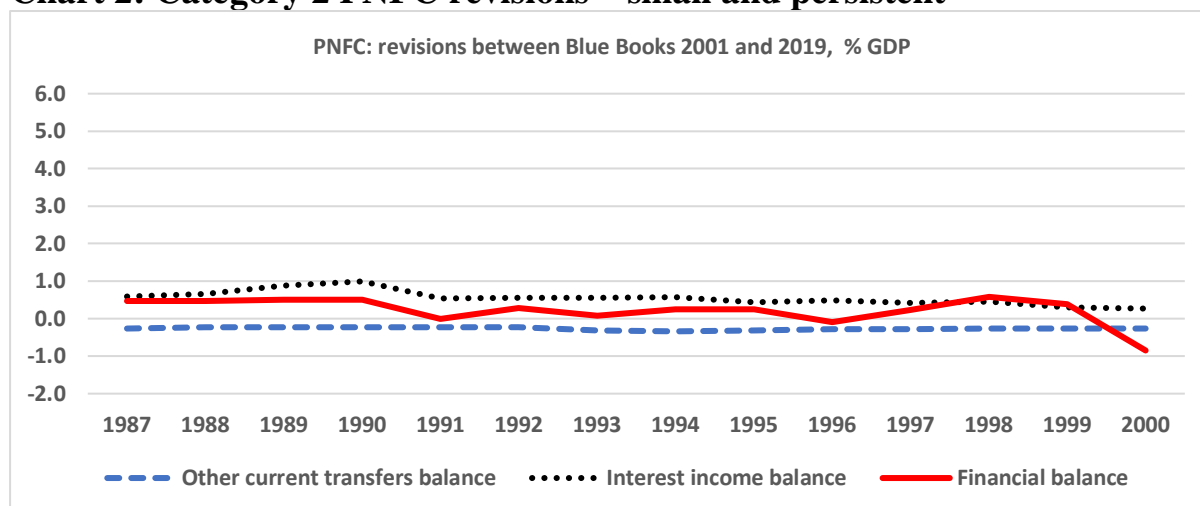| per cent of latest GDP	1987	Annual average, 1987 to 2000
Gross operating surplus	3.7	3.3
Net property income	0.7	0.6
of which:		
Interest	0.6	0.6
Distributed income	0.0	0.0
Reinvested earnings on FDI	0.0	0.0
Other investment income	0.1	0.1
Taxes on income	0.0	-0.1
Net other current transfers	-0.3	-0.3
Saving	4.1	3.6
Gross capital formation etc.	3.7	3.4
of which:		
Gross fixed capital formation	3.7	3.4
Financial balance	0.5	0.2

Sources: 2001 Blue Book and *UK Economic Accounts* published 4Q 2019 (for 2019 Blue Book data). Notes: Differences calculated as the latest estimate minus the 2001 Blue Book estimates, expressed as per cent share of latest (2019 Blue Book consistent) estimates of GDP. Net property income is defined as receipts less payments. "Gross capital formation etc." comprises gross fixed capital formation, changes in inventories, the acquisition less disposal of valuables and the net acquisition of non-produced, non-financial assets. "FDI" – foreign direct investment. The table does not record the near zero revisions for rent (part of net property income), and zero revisions for capital taxes and net other capital transfers. Tabulated totals may not equate with the sum of parts due to rounding error.

Chart 1: Category 1 PNFC revisions – large and backwards increasing

Sources and notes: see Table 1

Chart 2: Category 2 PNFC revisions – small and persistent

PNFC: revisions between Blue Books 2001 and 2019, % GDP

Legend: - - - Other current transfers balance ····· Interest income balance ——— Financial balance
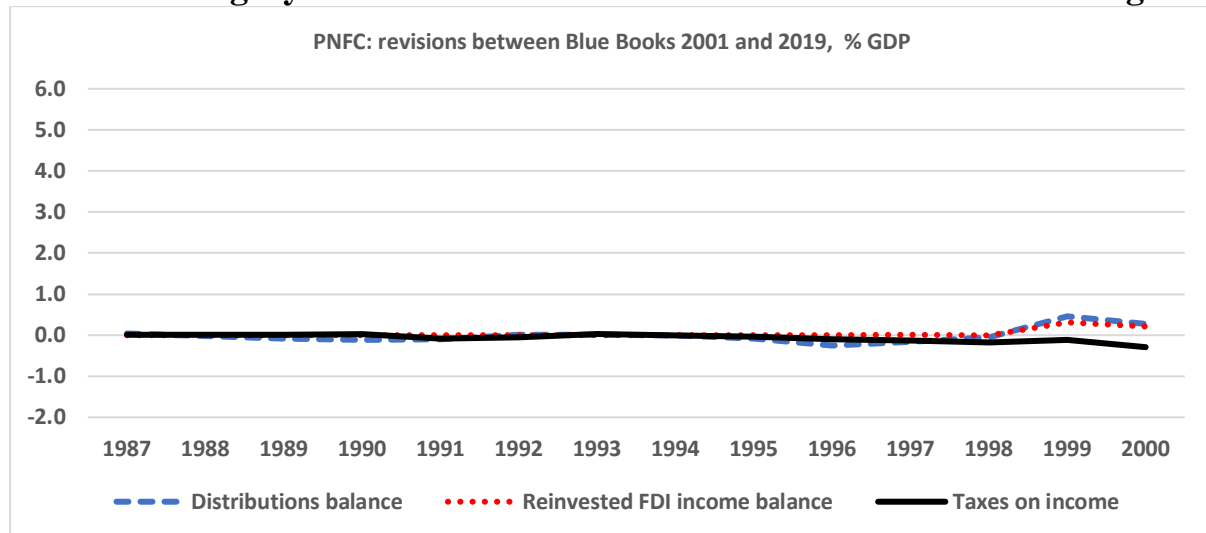
Sources and notes: see Table 1

Charts 1 and 2, each with the same vertical scale, make the same distinction. Chart 1 reveals the large ("category 1") revisions to PNFC gross operating surplus, saving and gross fixed capital formation, with the scale of revisions tending to increase rather than to diminish as one moves backwards in time (for want of a better short description: "backwards increasing"). A comparison can be drawn between the smaller, albeit still large, revisions – in the range from 1¼ per cent to 2½ per cent of GDP – in 2000 with the peak revisions, in the range of 4½ per cent to 5¼ per cent of GDP, seen ten years earlier. The revisions to gross operating surplus, saving and gross fixed capital formation in 1987, in the range from 3¾ per cent to 4 per cent of GDP, are less than those at the 1990 peak but still greater than those at the end of the overlapping period in the year 2000.

Chart 2, by contrast, shows the much smaller, but persistent, ("category 2") revisions that apply to three series: net other current transfers, net interest income and the financial balance. The downward revisions to net other current transfers are relatively stable, averaging ¼ per cent of GDP during the overlapping sample period. The revisions to what are inconsistently categorised as net interest income – interest receipts less payments – part of property income, tend to be backwards increasing, rising from ¼ per cent of GDP in 2000 to a peak of 1 per cent of GDP in 1990. The revisions to 1987 values of net interest income fall back to the overlapping sample period average of ½ per cent of GDP. Revisions to the PNFC financial balance are more volatile, ranging from between minus ¾ per cent of GDP in 2000 to ½ per cent of GDP in 1998. The revisions to the financial balance stabilise at the equivalent of ½ per cent of GDP in each one of the four years from 1987 to 1990.

To these two categories of revisions, Chart 3, drawn with the same vertical scale as Charts 1 and 2, adds a third. "Category 3" revisions are small during the overlapping sample period and tend to diminish in scale as one moves backwards in time (again, for want of a better short description: "backwards decreasing").

Revisions to each of PNFC net distributions, reinvested foreign direct investment (FDI) earnings and taxes on income fall in an absolute range between ¼ per cent and ½ per cent of GDP in 1999 and 2000 but are close to, if not, zero (to one decimal place) before 1996.

Chart 3: Category 3 PNFC revisions – small and backwards decreasing

PNFC: revisions between Blue Books 2001 and 2019, % GDP

Sources and notes: see Table 1

To complement these comparisons, Table 2 reports formal hypothesis tests of the equality of the means and variances of the 2001 Blue Book and 2019 Blue Book series over the 14-year overlapping period from 1987 to 2000. The results come with a strong qualification. In view of the very limited degrees of freedom, failure to reject null hypotheses of equality should not be taken as proof of likely equality in out-of-sample periods, although rejection of the null hypotheses of equality within the sample period provides a prima facie case to suspect continuing out-of-sample inequality.

Seen against the findings in Table 1 and Charts 1 to 3, it is not surprising that the null hypothesis of equality of means is strongly rejected in the case of the PNFC series for gross operating surplus, saving and gross fixed capital formation. Despite the small scale of the revisions between the 2001 and 2019 Blue Books, the same rejection applies to the means of series for net interest income, net other investment income and net other current transfers. The hypothesis of mean equality is not, however, rejected for the PNFC series for distributed income, reinvested earnings on FDI and the financial balance. In contrast to the mixed findings for sample means, the null hypothesis of equality of sample variances is generally not rejected. Even for series for which there is evidence of significant differences in means – gross operating surplus, saving and gross fixed capital formation, for example - it appears in each case that the two sample Blue Book representations of (notionally) the same economic variable move up and down in similar fashion.

Table 2: Equality tests of comparable PNFC series in 2001 Blue Book and 2019 Blue Book

Series, per cent of latest GDP	Mean equality tests p-values		Variance equality tests p-values	
Sample period: 1987 to 2000	t-test	S-W t-test	F-test	B-F test
Gross operating surplus	0.00*	0.00*	0.48	0.56
Net property income	0.03*	0.03*	0.98	0.96
of which:				
Interest	0.00*	0.00*	0.93	0.81
Distributed income	0.97	0.97	0.89	0.77
Reinvested earnings on FDI	0.53	0.53	0.12	0.38
Other investment income	0.00*	0.00*	0.00*	0.07
Taxes on income	0.72	0.72	0.97	0.89
Net other current transfers	0.00*	0.00*	0.11	0.05*
Saving	0.00*	0.00*	0.27	0.49
Gross fixed capital formation	0.00*	0.00*	0.25	0.72
Financial balance	0.67	0.67	0.86	0.93

Sources: see Table 1. Notes: * test rejects null hypothesis of equality of sample period means or variances at a 5% level of significance. S-W t-test: Satterthwaite-Welch t-test. B-F test: Brown-Forsythe (modified Levene) test. Tests performed using the software program Eviews® 11. Its manual provides a description of the robustness and power of these and other such tests.

The fact that some revisions have a backwards decreasing, and ultimately immaterial impact can be used to good effect, making tractable the task of resurrecting the PNFC historic accounts. The challenge that presents itself is to adjust the 2001 Blue Book PNFC data before 1987 so that they conform to today's standards of measurement, for which purpose it is necessary to trace the root causes of subsequent revisions, and to estimate their likely impact in the historic period. The challenge appears daunting. Since the 2001 Blue Book, the national accounts have been extensively revised each year and in a multitude of ways. In the 2019 Blue Book alone – not a bumper year – 40 changes can be counted. The 2014 Blue Book, with the introduction of ESA10, contained many more fundamental revisions. The typically limited timespan covered by official analysis of revisions, usually confined to the period since 1997, and the loss of older vintages of ONS datasets, documentation and of institutional memory compound the problem. It was perhaps an understatement of the "Historical National Accounts Data" project leaders at ESCoE to say that "The length of time elapsed since many of the methodological changes makes a reconciliation exercise especially difficult" (ESCoE, 2020, p43). At first sight, the task seems herculean, if not impossible.

The task would however become merely arduous, rather than herculean or impossible, were it possible legitimately to eliminate many revisions from the scope of the enquiry. Such elimination is possible. The revisions that can be eliminated are those that are either always negligible or otherwise strongly backwards decreasing such that they have no material impact on the 2001 Blue Book values recorded in 1987. The assumption underpinning this procedure is that the revisions having a negligible impact on 1987 values do not erratically re-appear and have a material impact in earlier years. This is arguably a weak assumption to make: the nature of most revisions is such that erratic behaviour of this sort is unlikely to occur. Exceptions may nevertheless arise as a result of dataset corruption and subsequent ONS amendments to values in the historic period. It is to mitigate such problems that the 2001 Blue Book dataset used for this exercise has been subjected to scrutiny and takes on board ONS corrections to PNFC gross operating surplus before 1963. The task thus resolves itself into identifying the revisions that have had an impact on 1987 values and estimating their likely enduring impact on the corrected 2001 Blue Book record in the historic period before 1987.

(ii) The nature of ONS revisions: regular versus irregular

The first step is to understand the origins of the type of revisions that are likely to prove enduring and non-negligible. Such an understanding can come from the high-level description of the ONS revision process provided in the "*GNI Inventory*" published in 2010 and in a series of official briefs, the last published as of this writing in November 2019. A distinction emerges from these descriptions between what may be called the "regular" annual round of revisions, which have a timespan-limited and backwards decreasing impact on the previously published record, and other, "irregular" revisions, which arise because of, for example, fundamental accounting changes and data reassessments, including the correction of mistakes. Although they may be timespan limited and have a backwards decreasing impact, irregular revisions may lead to the restatement of the full history of the national accounts, with no presumption that the revisions will diminish as one moves backwards in time.

In the period since the 2001 Blue Book, the annual rounds of regular revisions have followed a standard procedure, with some exceptions. Walton (2020) provides a useful summary of these rounds back to the 2004 Blue Book. Regular revisions occur each round as a result of the arrival of new information, such as the Annual Business Survey (previously known as the Annual Business Inquiry) and new data from HM Revenue and Customs. This late arriving information, more comprehensive than that originally available, has been used to benchmark the accounts, so constraining quarterly data to add up to more reliable annual data. Additionally, in most but not all rounds since the 2001 Blue Book, the accounts

have been balanced, or rebalanced, to bring into alignment the production, income and expenditure measures of GDP.

Full balancing has been undertaken in fine industry and product detail for selected years up to the latest year for which, at the time, a comprehensive set of input-output Supply and Use Tables (SUTs) were available. The SUTs balancing methodology has changed since the 2001 Blue Book, as is clear from a comparison of the descriptions given by, for example, Mahajan (2006), Akers and Clifton-Fearnside (2008), Wild and Whiting (2014), and Doody (2019). But each of the varying SUTs procedures has the common aim of removing production, income and expenditure data discrepancies at a disaggregated level. Not all Blue Book rounds have entailed a full re-balancing using the SUTs framework, however. Sometimes the historic SUTs have not been updated, or applied. In such cases, the ONS faced with new information has in more recent years resorted to a short-cut balancing approach: the required revisions have been introduced in such a way as to ensure that the production, income and expenditure measures of GDP are equally affected. The ONS refers to the short cut approach as "layering". As a senior ONS statistician notes, revisions introduced in a layered manner have "essentially been added on top of previous estimates of GDP" (Kent-Smith, 2020).

It can be deduced from this high-level description that revisions to the earliest estimates in the 2001 Blue Book are unlikely to be the result of the regular annual round of benchmarking and rebalancing. Regular revisions are typically carried back by the ONS for no more than a few years. The 2002 Blue Book, for example, which incorporated "no substantial methodological improvements", contained revisions to the 2001 Blue Book dataset back to, but not before, 1996 (2002 Blue Book, pp 42-43). The same starting date of 1996 was used for major revisions to current price data in the 2003 Blue Book (2003 Blue Book, pp 30-32). Even the exceptional 2019 Blue Book balancing exercise was not carried back before 1997.

The implication is that revisions to the 1987 values recorded in the 2001 Blue Book are most likely to be the result of irregular revisions, arising from fundamental accounting changes and data reassessments. The balancing process may also have played a role. As with regular revisions, the irregular amendments to the national accounts which have a fundamental impact should be assimilated in a way that maintains the equality of the rival estimates of GDP. For example, the editors of the 2007 Blue Book which introduced revised estimates of software expenditure describe how the "new estimates have been incorporated into the accounts using a simplified approach … possible because all three measures of GDP are affected equally, that is, it is a balanced revision." (2017 Blue Book, p30). The balancing process may itself lengthen the historic period during which the revisions have an impact. As an example, a new method of measuring
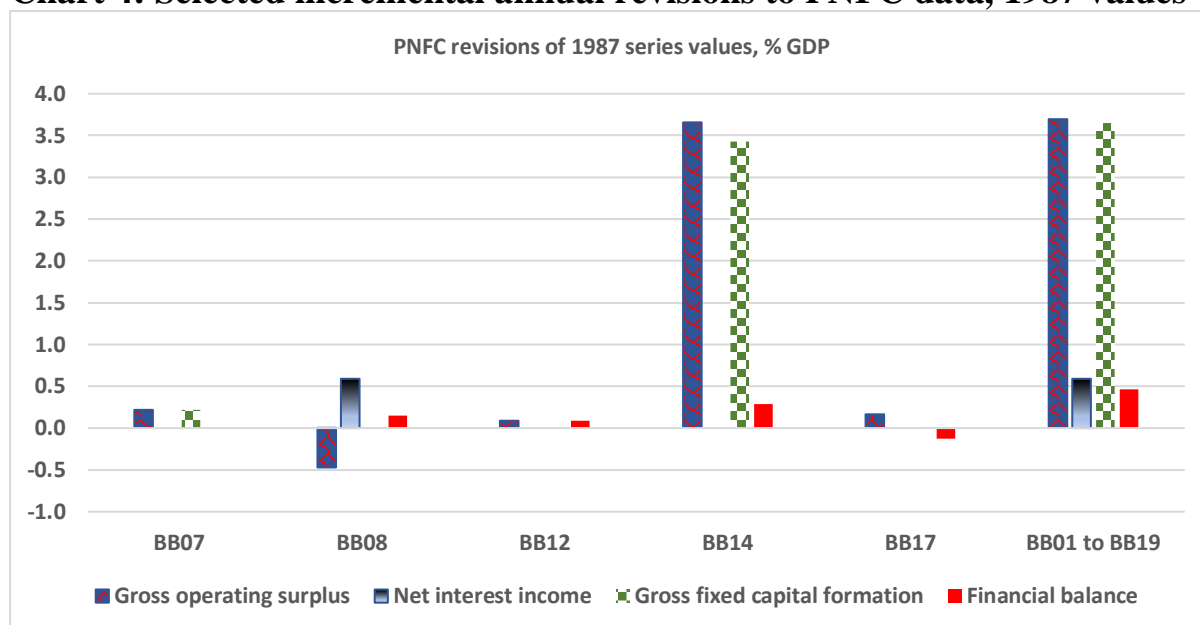
insurance services introduced in the 2012 Blue Book spurred the rebalancing of the accounts all the way back to 1987.

Table 3: Incremental annual revisions to PNFC data, 1987 values

Annual & cumulative revisions	Revision to 1987 values in previous year's accounts					2001 to
per cent of latest GDP	2007	2008	2012	2014	2017	2019*
Gross operating surplus	0.2	-0.5	0.1	3.7	0.2	3.7
Net property income	0.0	0.6	0.0	0.1	0.0	0.7
of which:						
Interest	0.0	0.6	0.0	0.0	0.0	0.6
Distributed income	0.0	0.0	0.0	0.0	0.0	0.0
Reinvested earnings on FDI	0.0	0.0	0.0	0.0	0.0	0.0
Other investment income	0.0	0.0	0.0	0.1	0.0	0.1
Taxes on income	0.0	0.0	0.0	0.0	0.0	0.0
Net other current transfers	0.0	0.0	0.0	0.0	-0.3	-0.3
Saving	0.2	0.2	0.1	3.7	-0.1	4.1
Gross capital formation etc.	0.2	0.0	0.0	3.4	0.0	3.7
of which:						
Gross fixed capital formation	0.2	0.0	0.0	3.4	0.0	3.7
Financial balance	0.0	0.2	0.1	0.3	-0.1	0.5

Sources: 2001 Blue Book and *UK Economic Accounts* typically published in the fourth quarter of the year's shown and consistent with that year's Blue Book. Because of delayed publication of pre-1997 values, the 2014 Blue Book revisions are based on *UK Economic Accounts* published in the second quarter of 2015. Notes: Annual revisions calculated as the latest estimates for 1987 minus the previous year's estimates for 1987, expressed as per cent share of latest estimates of GDP. Only years for which there are any non-zero (to one decimal place) revisions are shown. * The cumulative revision between Blue Book 2001 and Blue Book 2019 as in Table 1. Column and row parts may not add up to column and row totals because of rounding error. See also Table 1 notes.

Chart 4: Selected incremental annual revisions to PNFC data, 1987 values

PNFC revisions of 1987 series values, % GDP

Legend: Gross operating surplus, Net interest income, Gross fixed capital formation, Financial balance

Sources and notes: see Table 3. "BBxx" denotes the Blue Book published in year 20xx.

Rather than consider each and every revision since the 2001 Blue Book – as noted, a herculean task - a practical means needs to be considered that identifies those revisions that may have an enduring impact before 1987. Table 3 takes those revisions to be ones that have a "material" impact on 1987 values. "Material" is defined in a conservative fashion. The table records only revisions to 1987 values that, expressed as a per cent share of GDP, are greater or less than zero (to one decimal place). This criterion reduces the number of Blue Book rounds to be considered since the 2001 Blue Book to a more manageable five: those in 2007, 2008, 2012, 2014 and 2017. For each of these rounds, the table shows the revisions to the 1987 values of PNFC series compared with the previous year's set of accounts. These, then, are incremental annual revisions. Their cumulative sum is equal to the revision to 1987 values that occurred between the 2001 and 2019 Blue Books, as shown in Table 1 for the same series. Incremental annual revisions for four of the main series affected are depicted in Chart 4.

The selection criterion used in Table 3 has thus reduced a herculean task to a manageable one. To identify those revisions to the PNFC accounts that may have an enduring impact in the historic period before 1987, the table has eliminated from consideration (a) revisions in thirteen out of the eighteen Blue Book rounds since the 2001 Blue Book and, of the five Blue Book rounds that remain, (b) their revisions to the majority of the components of the PNFC sector accounts. While some have a large impact in later years, the excluded revisions are those that have a backwards decreasing and eventually negligible impact, zero or vanishingly small, on 1987 values, and, it is thereby assumed, no material effect on the (corrected) historic 2001 Blue Book record before 1987.

The process of elimination can be usefully formalised. The relevant, full set of potential revisions to the PNFC financial balance can be symbolically represented by identity (2):

$$\sum_{b=2002}^{b=2019} \nabla F_{n,t,b} \equiv \sum_{b=2002}^{b=2019} \left[\nabla \Pi_{n,t,b} + \sum_{i \in p} \nabla P_{n,i,t,b} + \sum_{i \in z} \nabla Z_{n,i,t,b} - \sum_{i \in x} \nabla X_{n,i,t,b} \right], \text{ for } t = 1960, \dots 2000 \qquad (2)$$

The annual observations, denoted by the time subscript "t", lie in the interval, from 1960 to the year 2000, that defines the span of observations on the PNFC financial balance available in the corrected 2001 Blue Book. On the left-hand side of the identity, "$\nabla F_{n,t,b}$" denotes the revision - the operator "∇" - to the value of the financial balance, as before, denoted "F", of the PNFC sector, denoted by the subscript "n". The revisions are those that appear in the Blue Book published in year "b". These are *incremental* revisions to the previous year's record in each round, from the 2002 Blue Book round to the 2019 Blue Book round. The cumulative sum of the incremental revisions to values in year "t" of the PNFC financial balance is denoted "$\sum_{b=2002}^{b=2019} \nabla F_{n,t,b}$". This sum, for t=1987 and expressed as a share of GDP, is equal to the figure of 0.5 per cent that appears in the first column and final row of Table 1.

The right-hand side of identity (2) shows, as a cumulative sum, the incremental annual revisions to the various component series that appear in a sequence of sector accounts which give rise to the financial balance. The component series shown are (1) gross operating surplus, denoted "Π", (2) property income balances, denoted "P", (3) current and capital account net transfers, denoted "Z", and (4) gross capital formation etc., denoted "X". Property income, transfer balances and gross capital formation etc., each comprise various series types, denoted by the subscript "i", which are cumulated in identity (2) over the relevant groupings, denoted respectively by "$\in p$", "$\in z$" and "$\in x$."

There are many series types in each of these groups. Property income balances include net interest income, net corporate distributions (receipts less payments of dividends and dividend-like withdrawals from partnerships), reinvested earnings on FDI, other investment income, itself split between income attributable to PNFC both as insurance policy holders and as shareholders in collective investment funds, and rent. Transfer balances include groups of transactions that by construction of the PNFC sector accounts sum to zero. But other transfers are not self-cancelling artefacts of national accounting: taxes on income, net other current and capital transfers, and capital taxes. Gross capital formation comprises gross fixed capital formation, changes in inventories, and the acquisition less disposals of valuables. Also included in the final group X are PNFC acquisitions less disposals of non-produced, non-financial assets.

The selection criterion underpinning Table 3 reduces the potentially very large number of revisions expressed in identity (2) by eliminating all component series and Blue Book rounds having a non-material impact on 1987 values. Component series eliminated comprise net corporate distributions, reinvested earnings on FDI, rent, taxes on income, net other capital transfers, capital taxes, changes in inventories, the acquisition less disposals of valuables and the net acquisition of non-produced, non-financial assets. The reduced set of revisions that require examination after these eliminations can be formally expressed in the approximate identity (3):

$$\sum_{b \in B} \nabla F_{n,t,b} \cong \sum_{b \in B} \left[\nabla \Pi_{n,t,b} + \nabla INT_{n,t,b} + \nabla OP_{n,t,b} + \nabla OZ_{n,t,b} - \nabla I_{n,t,b} \right], \text{ for } t = 1960, \ldots 1987 \qquad (3)$$

The identity is an approximate one since it ignores the minor impact of non-material revisions. The time period is now confined to the 1960 to 1987 interval since revisions to other series values after 1987 may be, and commonly are, material in later years. On the left-hand side of the identity, the set, denoted "$_{\in B}$", of relevant Blue Book rounds is reduced to the five previously noted (in 2007, 2008, 2012, 2014 and 2017). On the right-hand side, the revisions are limited to those to five series: gross operating surplus, net interest income, denoted "INT"; other investment property income, denoted "OP"; net other current transfers, denoted "OZ"; and gross fixed capital formation, denoted "I".

This formal statement omits two important features. First, today's national accounts provide an historic series for PNFC gross operating surplus from 1948. The cumulative revision before 1987 to gross operating surplus is therefore known, whereas revisions before 1987 to the remaining four series are unknown, and require estimation. Second, identity (3) does not recognise the relationships that exist between the revisions to the component series. Within a system of accounting, it would be a mistake to treat the revisions to each series as being independent. In particular, the revisions to net interest payments and to gross fixed capital formation are closely bound to the observed revisions to gross operating surplus. These inter-relationships can be exploited to aid the estimation of the unobserved revisions in the historic period before 1987. In order to assess those relationships and to throw light on the likely behaviour of the unobserved revisions in the historic period, it is necessary to turn to a root cause analysis of the reduced set of revisions since the 2001 Blue Book.

(iii) Revision root cause analysis and stages in resurrecting the historic PNFC accounts

Table 3 and Chart 4 immediately reveal the main source of the revisions. By far the largest came with the conversion to today's national accounting standard, ESA10, presented for the first time in the 2014 Blue Book. Amongst a host of changes, ESA10 widened the definition of intangible fixed capital formation and radically altered the accounting of those pensions – "defined benefit" (DB)

pensions - that are sponsored by employers and specify a set of benefits, typically a retirement pension related to employees' final salary. Alongside the conversion, the ONS simultaneously introduced a number of measurement changes unrelated to ESA10 standards. These changes included amendments to the methods of estimating both capital formation and the imputed value of the services – formally known by the acronym FISIM ("Financial Intermediation Services Indirectly Measured") - of banks and other loan-making financial corporations that come from their business of loans and deposit taking but for which full, explicit charges are not made. As Table 3 reveals, the revisions to 1987 values before and since the 2014 Blue Book are far more limited: the largest were to net interest income in the 2008 Blue Book and to net other current transfers in the 2017 Blue Book.

A systematic root cause analysis of all these revisions is presented in Annex B. In a deep dive into sometimes arcane matters of national income accounting, consideration is given to different classes of revisions - those concerning FISIM, the balancing by layering techniques of revised estimates of gross fixed capital formation, the impact of the actuarial valuation of DB pensions - and a number of other miscellaneous revisions that have no common theme. Listed by root cause, the following section presents a summary of this deep dive and the implications for the historic PNFC accounts.
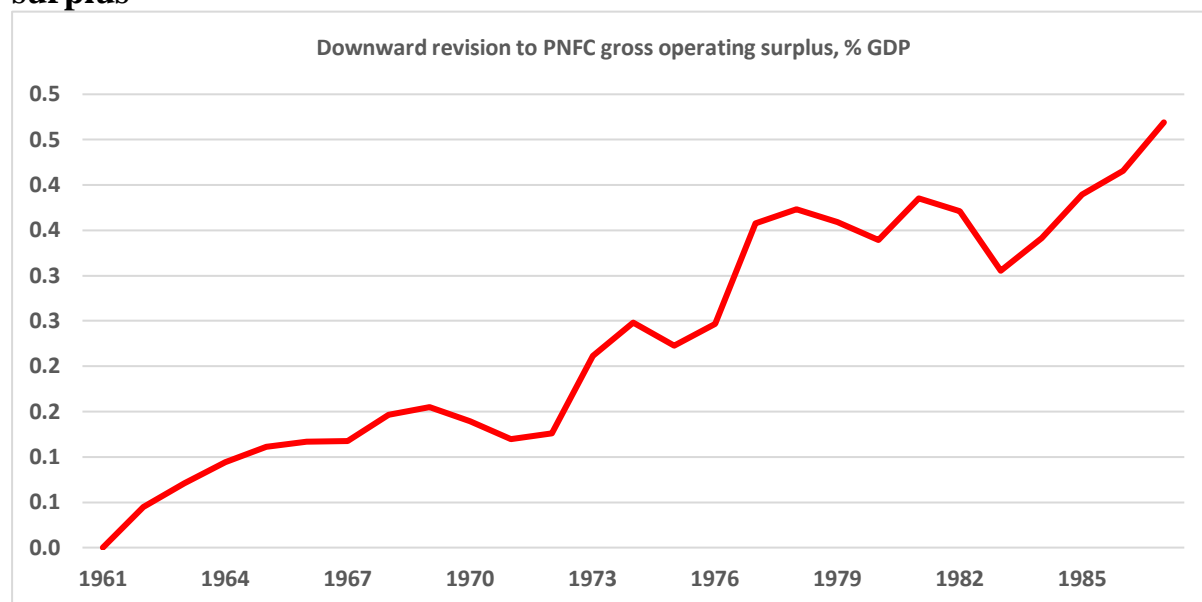
a) New FISIM and net interest income, 2008 Blue Book

A new method of accounting for the imputed services of banks and other financial intermediaries helps to explain the 2008 Blue Book downward revision to the 1987 value of PNFC gross operating surplus seen in Table 3, offset by an upward revision to PNFC net interest income. Gross operating surplus was depressed by the cost to PNFC of purchasing these financial services, their value being indirectly measured by an amended calculation of interest receipts and payments. The new FISIM revisions to gross operating surplus and to net interest income should have been of equal magnitude, one down, the other up, leaving PNFC saving and the financial balance unchanged. Under the previous "old FISIM" method - sometimes referred to as "the adjustment for financial services" – the imputed value of these financial services was not allocated to individual non-financial sectors.

Chart 5 shows the resulting revisions to PNFC gross operating surplus, or, with due regard to sign, the new FISIM-related revisions to net interest income. The revisions were volatile in the historic period, but generally backwards decreasing. The earliest revision in 1961 was zero. These revisions still stand. Datasets available up to the 2012 Blue Book show no further revision to the impact of FISIM on PNFC net interest income data before 1987. Subsequent datasets limited to the period since 1987 show no further new-FISIM revisions to PNFC interest income data before 1997.

There is one difficulty to be faced in applying these revisions to the 2001 Blue Book record. The revisions in the 2008 Blue Book to the 1987 values of PNFC gross operating surplus and net interest income were not exactly offsetting. Net interest income was revised up by more than gross operating surplus was revised down. Were this difference to be backcast before 1987, there would be a non-zero impact on PNFC saving and the financial balance as recorded in the (corrected) 2001 Blue Book. This outcome would not square with a presumption that the data revisions associated by new FISIM should have no impact on saving or the financial balance. The available official documentation, then or later, does not shed much light on the discrepancy between the revisions to gross operating surplus and net interest income. A contemporary account of the effect on financial balances notes that, outside the financial corporations sector, "the allocation of FISIM has merely reallocated revenue and expenditure flows from the income and capital account to the production account, with in theory (though not exactly in practice) no impact in aggregate" (Meader and Tilly, 2008). The authors do not elaborate why theory and practice differed. It was documented much later in 2016 that a correction of a FISIM calculation error led to a downward revision to PNFC gross operating surplus.

Chart 5: Impact of 2008 Blue Book new FISIM on PNFC gross operating surplus

Sources and notes: see Table 3. The chart traces downward revisions with reverse sign. These exactly match the historic data for the impact of FISIM on PNFC net interest payments taken from the "X15" Supplementary Tables published in ESA95 *UK Economic Accounts* releases before 2013.

A crude attempt is made to capture the small unexplained residual between the revisions to PNFC gross operating surplus and to net interest income. The 2008 Blue Book downward revisions to gross operating surplus in the historic period are scaled so that the concurrent upward revision to net interest income in 1987 is exactly offset. The impact of the scaling is small, equivalent at most to 0.1 per cent of GDP, and is backwards decreasing: it disappears by the early-1970s.

The procedure can be stated made formally. Denoting the 2008 Blue Book revisions to gross operating surplus as "$\nabla\Pi_{n,t,BB08}^{Fisim}$", and the scaling factor to equate, with appropriate sign, the revisions to 1987 values of gross operating surplus and of net interest income as "α", the assumption for the historic period can be expressed as: $\sum_{b \in B} \nabla INT_{n,t,b} = -\alpha\left(\nabla\Pi_{n,t,BB08}^{Fisim}\right)$.

With this substitution, identity (3) becomes:

$$\sum_{b \in B} \nabla F_{n,t,b} \cong \sum_{b \in B} \left[\left\{ \nabla\Pi_{n,t,b} - \alpha\left(\nabla\Pi_{n,t,BB08}^{Fisim}\right)\right\} + \nabla OP_{n,t,b} + \nabla OZ_{n,t,b} - \nabla I_{n,t,b} \right], \text{ for } t = 1960, \dots 1987 \quad (4)$$

As with identity (3), identity (4) shows that the cumulative Blue Book revisions to values of the PNFC financial balance recorded in the 2001 Blue Book in and before 1987 are to be equated with the summation of cumulative revisions to five series, including other investment income, net other current transfers and gross fixed capital formation. The difference with identity (3) is that the term in net interest income has been eliminated, making the revision to the financial balance dependent on the revisions to gross operating surplus *other* than those associated with new FISIM.

   b) Revisions to fixed capital formation, 2007 and 2014 Blue Books

Attention now turns to the revisions to the 1987 values of PNFC gross fixed capital formation, which occurred in the 2007 and 2014 Blue Book rounds. The key question concerns the scale of the related revision to the 1987 value of gross operating surplus. The answer is that all of the upward revision to PNFC gross operating surplus in the 2007 Blue Book and most of the upward revision to PNFC gross operating surplus in the 2014 Blue Book as recorded in Table 3 stem from the same cause: the incorporation of new estimates of intangible gross fixed capital expenditure.

In the 2007 Blue Book, estimates of computer software expenditure were revised up from 1970. The resulting addition to the expenditure measure of GDP was balanced by an equal addition to the income measure of GDP. Although sector considerations did not become a formal part of the ONS balancing process until the 2019 Blue Book round (Doody, 2019), the layered balancing method adopted in the 2007 Blue Book meant that PNFC gross fixed capital formation and PNFC gross operating surplus were revised up by the same amount, leaving the financial balance unaffected. The equality of the 2007 Blue Book revisions to the two series

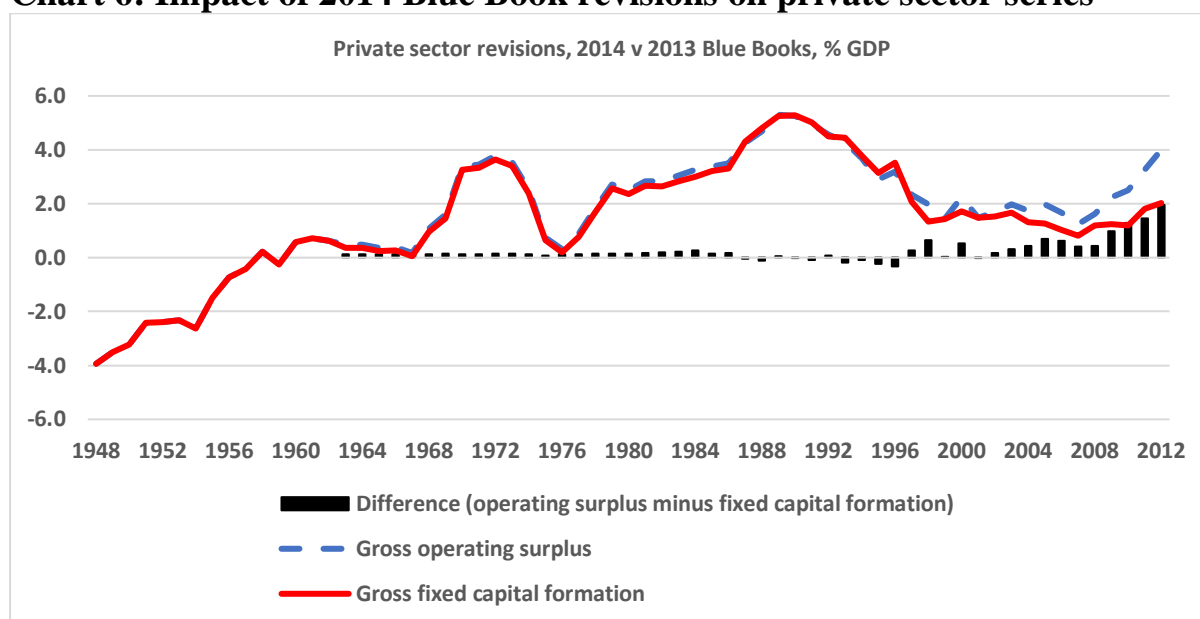and the zero impact on the PNFC financial balance is observed each year in the interval from 1987 to 2004.

A similar balancing process came into play in the 2014 Blue Book with the extension of the fixed capital asset boundary to include expenditure on Research and Development (R&D). The revision to the expenditure measure of GDP invited a like revision to the income measure of GDP. However, as Table 3 shows, the upward revision to the 1987 value of PNFC gross fixed capital formation was a little smaller than the upward revision to the value of PNFC gross operating surplus. The difference in 1987 was equivalent to ¼ per cent of GDP. The reasons for this small difference are not easily deduced from the available official documentation. The difference may be connected with the way the ONS chose to backcast its gross fixed capital formation data for the whole economy before 1997, using new linking factors. The difference may well have arisen because gross operating surplus was revised for reasons unconnected with the revisions to gross fixed capital formation. The new method of evaluating DB pensions had a small depressive impact on the 1987 value of PNFC gross operating surplus, but no impact on gross fixed capital formation. Other changes acting upwardly to revise PNFC gross operating surplus may have come from new ONS calculations affecting the sector accounts for non-profit institutions serving households (NPISH).

Whatever the cause of the difference, some account of it is required in order to backcast the missing history of gross fixed capital formation. The missing history may be inferred by amending the 2001 Blue Book record of gross fixed capital formation using the relevant incremental revisions to gross operating surplus. The challenge to this assumption is self-evident: this procedure is valid only to the extent that the revisions to gross operating surplus exactly represent balanced revisions to gross fixed capital formation. The 2007 Blue Book revisions pose no problem: historic revisions to both series can be assumed legitimately to be equal. But this is not the case with the 2014 Blue Book revisions. There is a difference that separates the revisions to 1987 values of PNFC gross operating surplus and of gross fixed capital formation, and no observable history of the difference before 1987.

It is fortunately possible to turn for guidance from the 2014 Blue Book revisions to equivalent private sector series, of which revisions to PNFC series can be presumed to form a large part. Unlike the PNFC revisions, those to private sector gross operating surplus and to private sector gross fixed capital formation are observable in the historic period: private sector data can be constructed by deducting from economy-wide totals the equivalent series for general government and public corporations. As Chart 6 shows, the difference, so calculated, between revisions to private sector gross operating surplus and to gross fixed capital formation are small: in and before 1987, equivalent to no more than ¼ per cent

of GDP, and backwards decreasing. Before 1963, the difference is zero. In the 1948 to 1962 interval the revisions to both private sector series are equal.

Chart 6: Impact of 2014 Blue Book revisions on private sector series

Private sector revisions, 2014 v 2013 Blue Books, % GDP

Legend:
- Difference (operating surplus minus fixed capital formation)
- Gross operating surplus
- Gross fixed capital formation

Sources: *UK Economic Accounts* published in 4Q 2013 and in the second quarters of 2011 and 2015; national accounts consistent PSAT published 4Q 2013 and 2Q 2015. Notes: Economy-wide gross operating surplus data missing before 1987 in the published 2014 Blue Book and related *UK Economic Accounts* are taken to be equal to the 2015 Blue Book series roughly adjusted for the small revisions in 1985 and 1986 noted in Banks et al. (2015). *UK Economic Accounts* published 2Q 2011 were the last to provide data before 1987 on the net acquisition on non-produced, non-financial assets of general government and public corporations. These archived estimates are deducted from the PSAT data to derive series before 1987 for general government and public corporations gross fixed capital formation. The private sector data are derived by residual: whole economy less public sector (general government plus public corporations).

Also to be noted in passing are the counterintuitive, likely wrong, downward revisions to gross fixed capital formation before 1960, as of this writing a puzzle accepted, but still not resolved, by the ONS. The downward revisions in the 2014 Blue Book that persist in today's records mean that in 1948 private sector gross fixed capital formation was in excess of 50 per cent below that recorded in the last ESA95 Blue Book published in 2013. The shortfall is equivalent to a reduction of about 4 per cent in the level of GDP. Also unexplained are the marked oscillations in the scale of the revisions to the national as well as to the private sector record of gross fixed capital formation, from notable highs in the first half of the 1970s to notable lows in the mid-1970s. The ONS has begun a thorough reappraisal of the gross fixed capital formation data with a delivery date for what may be prove to be far reaching amendments pencilled in for the 2021 Blue Book. A more immediate correction of the data before 1960 may come
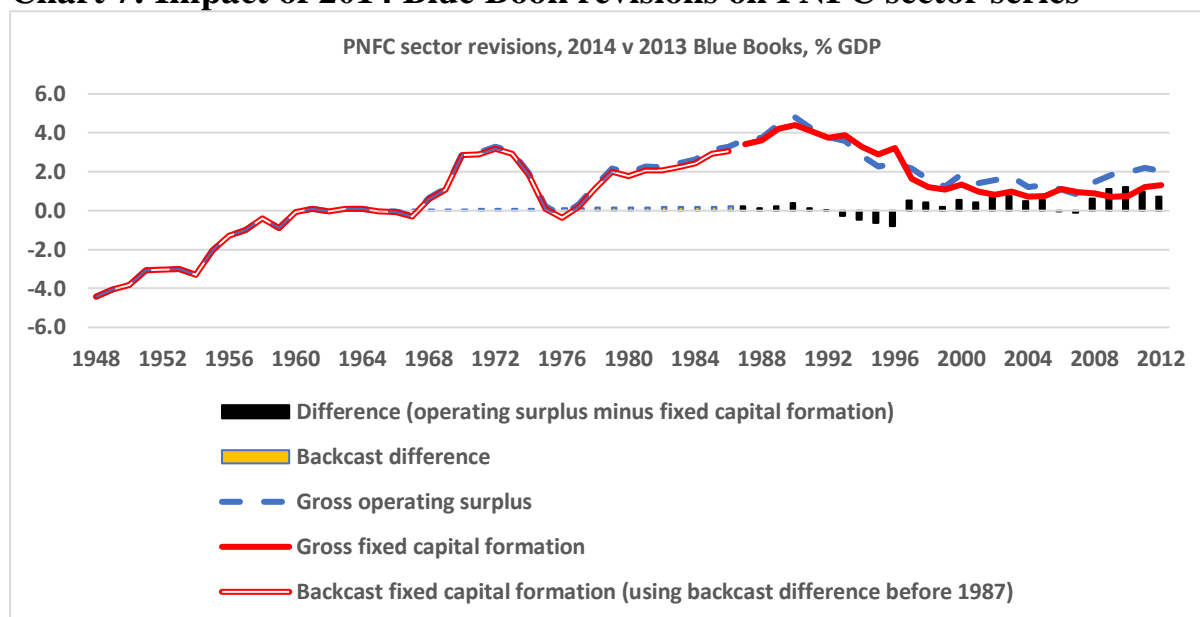
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sooner (ONS private correspondence, March 2020). The estimation methods here and in Martin (2019) are designed to accommodate such alterations but otherwise take the official record as a constraint with which the resurrected accounts must comply.

Progress on the matter in hand is possible because reservations about the existing national accounts data do not prevent reasonable inference about the likely *difference*, in the historic period, between the 2014 Blue Book revisions to PNFC gross operating surplus, which are observed, and the unseen revisions to gross fixed capital formation. The private sector pattern suggests two relevant conclusions: first, that the revisions to private sector gross fixed capital formation were balanced by revisions to private sector gross operating surplus, thus preserving at a sector level the equality of the income and expenditure measures of activity and, second, that the differences between the revisions to the two private sector series were very small by comparison with the scale of revisions to each series alone. The difference between the revisions to the two series was moreover backwards decreasing, falling to zero in 1962. It seems reasonable to assume that the same pattern is true of the equivalent PNFC revisions. Specifically, it is assumed that the revisions to PNFC gross fixed capital formation in the historic period were exactly balanced by revisions to gross operating surplus, and, second, that moving backwards in time through the historic period the remaining difference between the revisions to the two series gradually fell to zero in 1962.

The results of these assumptions are shown in Chart 7. Granted the backcast difference in the revisions to the two series – estimated using simple linear interpolation - the record of the 2014 Blue Book revisions to PNFC gross fixed capital formation can be inferred for all years from 1986 back to 1948. Not surprisingly, the picture is similar to that observed for the private sector as a whole. PNFC gross fixed capital formation accounts for around two-thirds of the private sector total, and has a similar degree of volatility around the mean.
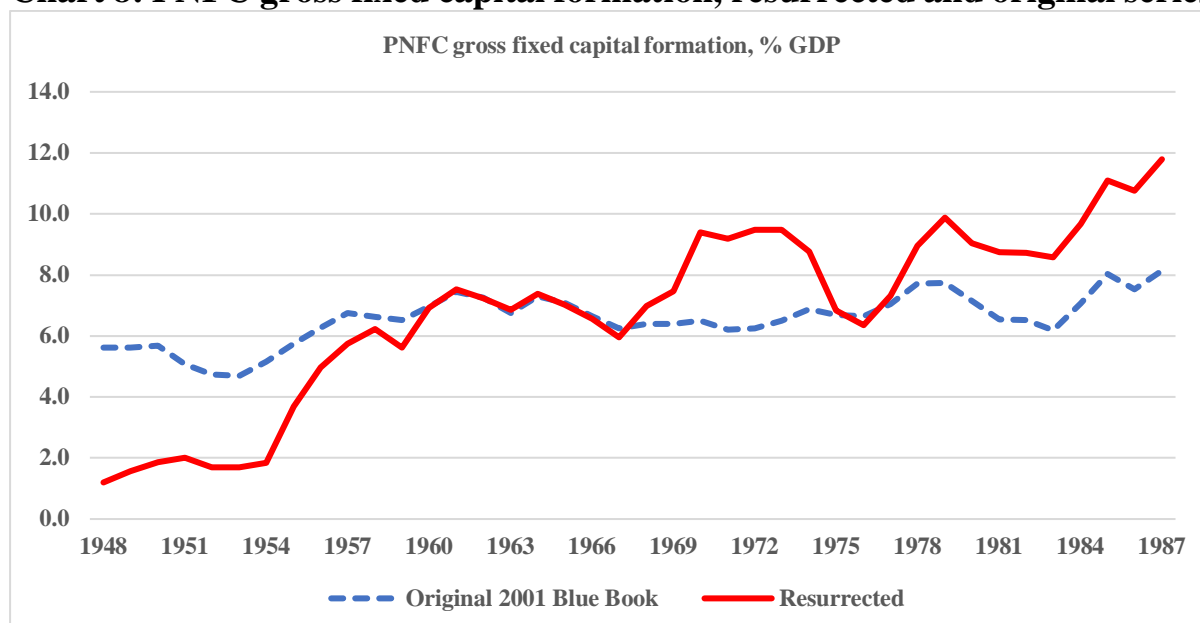
By adding together the historic revisions, actual and inferred, to PNFC gross fixed capital formation in the 2007 and 2014 Blue Books, and by applying this sum to the 2001 Blue Book record, one can resurrect the historic estimates of PNFC gross fixed capital formation back to 1948. These are shown in Chart 8 alongside the original series. The resurrected series inherit the suspected weaknesses of the official gross fixed capital formation data for the whole economy and private sector. Other errors will arise from any deficiency in the assumption that 2014 Blue Book revisions to gross operating surplus are representative of contemporaneous but unobserved revisions to gross fixed capital formation. In their defence, the resurrected PNFC data are arguably superior to alternatives that rely on mechanical splicing and pro-rating methods that take no account of the likely balanced nature of ONS revisions.

Chart 7: Impact of 2014 Blue Book revisions on PNFC sector series

PNFC sector revisions, 2014 v 2013 Blue Books, % GDP

■ Difference (operating surplus minus fixed capital formation)

▬ Backcast difference

- - - Gross operating surplus

▬▬ Gross fixed capital formation

▬▬ Backcast fixed capital formation (using backcast difference before 1987)

Sources *UK Economic Accounts* published in the fourth quarter of 2013 and second quarter of 2015. Notes: The difference between the revisions to gross operating surplus and gross fixed capital formation is backcast before 1987 by linear interpolation, with a value of zero assumed by 1962.

Chart 8: PNFC gross fixed capital formation, resurrected and original series

PNFC gross fixed capital formation, % GDP

- - - Original 2001 Blue Book   ▬▬ Resurrected

Sources and notes: see Chart 7.

By comparison with the data for gross fixed capital formation, the 2001 Blue Book historical record of PNFC financial balance requires comparatively little revision as a result of the 2007 and 2014 Blue Book changes. Balanced revisions to gross operating surplus and gross fixed capital formation have no impact on the financial balance. The revision to the PNFC historic financial balance as a result of the 2014 Blue Book revisions is confined to the small residual change to gross operating surplus that is not attributable to the balancing of revisions to gross fixed capital formation.

The point can be usefully formalised as follows. The sum of historic revisions to gross fixed capital formation, confined to those in the 2007 and 2014 Blue Books, can be equated with the balanced component of contemporaneous revisions to gross operating surplus. With the latter denoted "$\nabla\Pi_{n,t,BB0714}^{Ibalanced}$", it is the case that: $\sum_{b\in B}\nabla I_{n,t,b}\equiv\nabla\Pi_{n,t,BB0714}^{Ibalanced}$. Substitution of this expression in identity (4) yields a revised identity for revisions to the PNFC financial balance in the historic period:

$$\sum_{b\in B}\nabla F_{n,t,b}\cong\sum_{b\in B}\left[\left\{\nabla\Pi_{n,t,b}-\alpha\left(\nabla\Pi_{n,t,BB08}^{Fisim}\right)-\nabla\Pi_{n,t,BB0714}^{Ibalanced}\right\}+\nabla OP_{n,t,b}+\nabla OZ_{n,t,b}\right], \ t=1960,\ ...\ 1987 \ (5)$$

As with identities (3) and (4), identity (5) shows that the cumulative Blue Book revisions to the PNFC financial balance in the historic period are to be equated with the summation of revisions to five series. The difference with identity (4) is that the cumulative revision to the financial balance is now shown to be dependent on the revisions to gross operating surplus *other* than those associated with (a) the new FISIM calculations introduced in the 2008 Blue Book *and* (b) the revisions to gross fixed capital expenditure introduced in the 2007 and 2014 Blue Books. The residual item is small.

c) Other revisions

Attention turns finally to the impact of miscellaneous revisions, considered under three headings: other investment property income ("*OP*" in identity (5)), net other current transfers ("*OZ*" in identity (5)), and all the remaining revisions to gross operating surplus.

The precise reason for the revision to PNFC *other investment income* has not been traced. Amongst the many other changes in the 2014 Blue Book, revisions were applied to convoluted transactions that describe the property income flows that insurance policy holders, including PNFC, are deemed to receive from insurers as a result of the investment of insurers' reserves. The national accounts are compiled as if this investment income is paid first to the insurance policy holders and then paid out again in the form of consumption of insurance services. Although formally satisfying the criterion of a material revision, the revision to the 1987 value of PNFC other investment income is a rounding error away from

zero, and similarly tiny in later years. A zero value is assumed for the historic period.

Revisions to PNFC *other current transfers* income came as a result of upward revisions in the 2017 Blue Book to the value of the donations and grants received by non-profit institutions, such as universities and charities. PNFC make some of these donations. Chart 2 shows the steady nature of the resulting downward revision to PNFC net other current transfers – receipts less payments - expressed as a share of GDP. With no further information available, it is assumed that a downward revision of the same magnitude – about ¼ per cent of GDP – applies in the historic period.
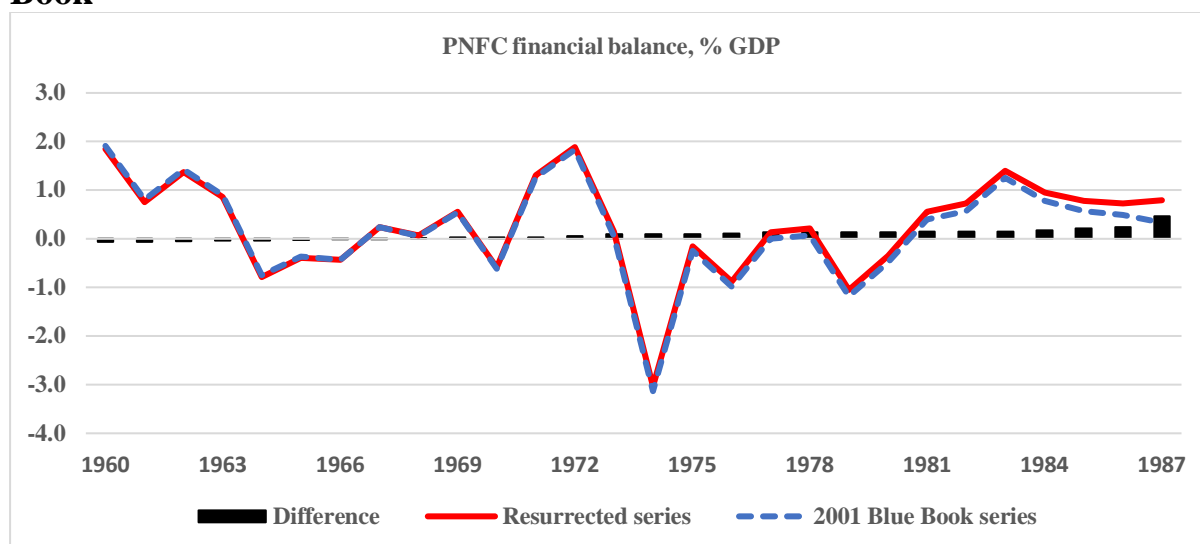
It is assumed that all other revisions are adequately captured by the observable residual revision to PNFC gross operating surplus, as formalised by the expression within curly parentheses in identity (5). This assumption rolls together a number of separate revisions, the root causes of which are not always traceable. It is, for example, likely that the upward revision to gross operating surplus in the 2012 Blue Book stems from revisions to insurance industry output. There were downward revisions to PNFC gross operating surplus as a result of the ESA10 DB pension changes, but the impact, calculated in Annex B, was backwards decreasing and likely very small in 1987. The causes of the upward revision to gross operating surplus in the 2017 Blue Book are unclear. Impossible to trace are any revisions to gross operating surplus due to undocumented changes to balancing adjustments.

iv) Resurrected PNFC financial balance: estimates and robustness tests

The preceding sections have described a number of steps to adjust the 2001 Blue Book data, selected as the best available statement of historic ESA95 PNFC accounts, to conform with the latest ESA10 accounting standard and measurement practices. The steps comprised (1) the correction of the 2001 Blue Book data for a financial balance identity breach before 1987 and a correction of an error affecting gross operating surplus before 1963 (2) a selection criterion that removed from consideration many possible sources of revision, (3) the linking, based on a root cause analysis, of revisions to net interest income and to gross fixed capital formation that are unobserved in the historic period with the revisions to gross operating surplus that are observed, and (4) simple estimation of residual factors having a small effect on the financial balance in the historic period before 1987. These residual factors combine the impact of the downward revision in the 2017 Blue Book to net other current transfers and the cumulative revisions since the 2001 Blue Book to the corrected PNFC gross operating surplus series in the historic period that are not associated with new FISIM introduced in the 2008 Blue Book or the balanced revisions to gross fixed capital formation in the 2007 and 2014 Blue Books.

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The small-scale impact of these residual factors on the PNFC financial balance is brought out by Chart 9, which contrasts the corrected 2001 Blue Book data with the resurrected series, calculated by adding the cumulative revisions. The impact of the residual factors is sharply backwards decreasing, falling to the equivalent of 0.1 per cent of GDP in 1981 and zero in 1971. The corrected 2001 Blue Book and resurrected financial balance series therefore trace a very similar path.

Chart 9: PNFC financial balance: resurrected versus corrected 2001 Blue Book

Sources: 2001 Blue Book; my calculations. Notes: The 2001 Blue Book financial balance is incorrectly calculated in the ONS dataset. The chart uses a corrected series that (a) aligns the financial balance with 2001 Blue Book PNFC saving and capital account data before 1987 and (b) adjusts the 2001 Blue Book PNFC saving and financial balance series before 1963 to reflect ONS corrections to GDP(I) and the national accounts residual error. The associated corrections to PNFC gross operating surplus before 1963 are equated with those observed in the 2006 Blue Book. See notes to Table 1.
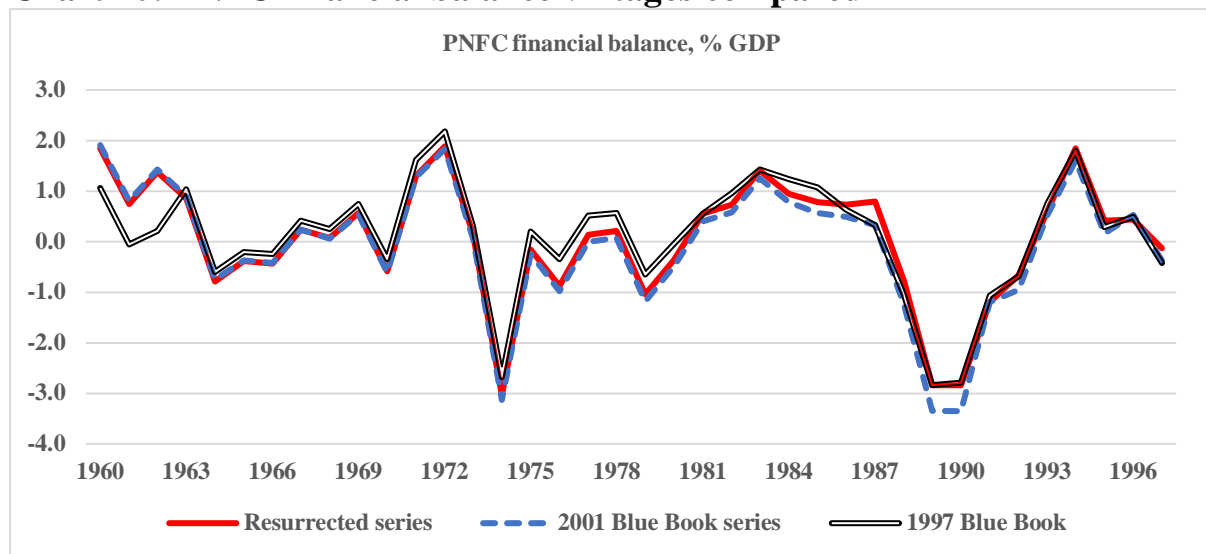
This result is reassuring in so far as it might be expected that financial balance data of different vintages are isomorphic representations of the same economic variable that is never perfectly observed. The expectation is based on the knowledge that the major revisions to the 2001 Blue Book data have been balanced revisions: those affecting net interest income, gross operating surplus and gross fixed capital formations should not have altered the record of the PNFC financial balance.

Further to test that expectation, the comparisons can be usefully extended to include the pre-ESA95 dataset, as in Chart 10. The time span includes data up to 1997 with the resurrected series extended after 1986 using the latest official PNFC data. The extended resurrected series and the pre-ESA95 "1997 Blue Book" series follow a similar path that is sufficiently close that the null hypotheses of equality of means and variances are not rejected, as Table 4 reports.

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It is also the case that all the vintages of the PNFC financial balance series appear to revert to a normal level, at least in the period since 1960. Formal tests that posit the opposite null hypothesis of non-stationary behaviour are rejected. Table 5 reports these tests for each series individually and as a group.

Collectively, these tests do not contradict the expectation that different vintages of the PNFC financial balance are isomorphic representations of the same variable. However, it is evident that the resurrected series and the corrected 2001 Blue Book series do depart at times from the pre-ESA95 1997 Blue Book series. The largest departures occur before 1963 in the 1960 to 1962 interval. As Annex A details, the proximate cause can be traced to the behaviour of the national accounts residual error. The reason for the shift in behaviour before 1963 is unclear. It is known that, in the conversion to ESA95, the ONS put through a number of undocumented long-run revisions which may be responsible for the amended way in which the ONS treated the differences between GDP(E) and GDP(I). Whatever the explanation, these revisions were, by definition, not balanced. The resulting impact on the PNFC financial balance record supports the decision not to use the pre-ESA95 data.

Chart 10: PNFC financial balance vintages compared

Sources and notes: See chart 9.

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Table 4: PNFC financial balance series of different vintages, equality tests

Series, per cent of latest GDP	Mean equality tests p-values		Variance equality tests p-values	
Sample period: 1960 to 1997	t-test	S-W t-test	F-test	B-F test
Resurrected v 2001 Blue Book	0.65	0.65	0.74	0.89
Resurrected v 1997 Blue Book	0.84	0.84	0.78	0.69
2001 v 1997 Blue Books	0.51	0.51	0.54	0.60

Sources: my calculations; 2001 Blue Book; *UK Economic Accounts* published second quarter 1998 ("1997" Blue Book). Notes: After 1986, the resurrected series is extended using the latest available official data. The 2001 Blue Book series is corrected for dataset calculation errors. Results do not reject null hypothesis of equality of sample period means or variances at a 5% level of significance. S-W t-test: Satterthwaite-Welch t-test. B-F test: Brown-Forsythe (modified Levene) test. See notes to Table 2.

Table 5: PNFC financial balance series of different vintages, unit root tests

Financial balance, % of GDP:1961 to 1997	Univariate tests p-values			Group tests p-values		
	ADF	DF-GLS	PP	LLC	IPS	F-ADF
Resurrected	0.01	0.00	0.01	na	na	na
2001 Blue Book	0.01	0.01	0.01	na	na	na
1997 Blue Book	0.01	0.00	0.01	na	na	na
All	na	na	na	0.00	0.00	0.00

Source: my calculations. Notes: "ADF" – Augmented Dickey-Fuller; "DF-GLS" – Dicky Fuller test with generalised least squares detrending "PP" – Phillips Perron; Group tests: "LLC" – Levin, Lin and Chu; "IPS" Im, Pesaran and Shin; "F-ADF" – Fisher ADF. The sample period selected, 1961 to 1997, ensures that the number of observations (37) is the same for each test. All tests posit a null hypothesis of a unit root, which the results reject at a 5% level of significance. Tests performed using the software program Eviews® 11 and its default settings. Its manual provides a description of the tests.

v) Resurrected PNFC accounts

The resurrected financial balance series is a key result that aids the resurrection of the series for PNFC gross disposable income, or corporate "saving". PNFC saving data can be resurrected back to 1960 in two ways, the first using an identity comprising components on capital account; the second using an identity comprising components on "current" account (formally, the allocation of primary income and secondary distribution of income accounts). Self-evidently, the two methods should produce the same result, and it is a check on the arithmetic that they in fact do.

The capital account identity can be written as:

$$S_n \equiv F_n + X_n - KTR_n \tag{6}$$

Saving, denoted S, is the sum of the financial balance, "F", and gross capital formation etc., "X", less net capital transfers, denoted "KTR". Net capital transfers are equal to PNFC receipts of items like investment grants less PNFC payments of capital taxes and of other capital transfers.

The current account identity can be written as:

$$S_n \equiv \Pi_n + P_n + CZ_n \tag{7}$$

In addition to the notation introduced with identity (2), "CZ" denotes net current transfer income – receipts less payments – comprising taxes on income and the miscellany of net other current transfers.

Using these identities and both the resurrected and, as appropriate, unrevised 2001 Blue Book series, it is possible to backcast most of the PNFC sector variables. Saving and the financial balance are taken back to 1960. Some items have a longer time span. Table 6 itemises the resurrected series starting dates, distinguishing between those series that stay in their original unrevised form and those that are recalculated. The main limitation concerns the components of property income. Series for net interest income and net distributed income cannot be backcast before 1984, the limit imposed by the absence of prior data in the 2001 Blue Book. A series for the trivial amounts of investment income attributable to PNFC, regarded as owners of insurance policies, can be taken back to 1960, assuming that the zero entries in the 2001 Blue Book before 1975 are reliable. Rent income data are available back to 1948. Other sources can be used to backcast to 1960 the far more important series for reinvested FDI earnings. Annex C gives details of the FDI calculations which draw on pre-ESA95, ESA95 and latest balance of payments ("Pink Book") sources.

Table 6: Resurrected PNFC series before 1987: summary sources and notes

PNFC series	Start	Sources & notes
Recalculated series		
Financial balance	1960	Blue Books: 2006, 2007, 2008, 2014, 2017, see text
Gross fixed capital formation	1946	Blue Books: 1997, 2001, 2007, 2014, see text
Saving	1960	Inferred by identity, see text
Net other current transfers	1955	Blue Books 2001, 2017, see text
Net property income	1960	Blue Books: 2001, 2008, see text
Net interest income	1984	Blue Books: 2001, 2008, see text
Reinvested earnings on FDI	1960	Blue Books 1997, 2001; 2019 Pink Book, see text
Other series		
Gross operating surplus	1948	2019 Blue Book
Distributed income	1984	2001 Blue Book
Other investment income	1960	2001 Blue Book
Rent	1948	2001 Blue Book
Taxes on income	1960	2001 Blue Book
Social insurance balance	1948	Zero by convention
Net other capital transfers	1948	2001 Blue Book
Capital taxes	1948	2001 Blue Book
Changes in inventories	1946	Blue Books: 1997, 2001, see text.
Other gross capital formation etc.	1948	2001 Blue Book (zero before 1986)

Notes: "Start" records the earliest year from which the resurrected data are available. The last year in the historic period is 1986, after which all data are available from the ONS sector accounts. The fullest set of resurrected PNFC data begins in 1960. Blue Book year references under "Sources & notes" refer equivalently to *UK Economic Accounts* publications: see notes to Table 3. Saving data, inferred from the capital account identity, are consistent with the current (primary and secondary) account identities, and with the property income balance directly calculated from its components from 1984. Data for gross fixed capital formation are backcast before 1948 using spliced 1997 Blue Book data for the ICC sector. The latter are backcast before 1963 using a constant share of private corporate sector gross fixed capital formation. Data for changes in inventories are taken from the 1997 Blue Book before 1960: see annex D.

4) Resurrecting the financial corporations sector accounts

Attention now turns to the resurrection of the data for the other main corporate sub-sector comprising financial corporations. It is a comparatively simple matter to use the resurrected PNFC sector accounts for this purpose. The historic data for a limited number of financial corporations series, including saving and financial balance, can be derived residually, beginning in 1960, by subtracting PNFC series from the corresponding private corporate sector series. The historic private corporate sector series, limited to a number of key variables including gross operating surplus, saving and capital account items, are in turn derived by subtracting the resurrected household sector series, also limited in scope, from the corresponding private sector series. The private sector series are derived in much greater detail from national accounts, public sector finances and balance of payments series.

The one complication in an otherwise straightforward arithmetic process concerns the household sector historic capital account. This needs to take on board the PNFC data for capital formation, and notably the backcast gross fixed capital formation series. A recalibration is required because the mechanical methods used for the household sector impose a constraint so that the backcast series for households and the relevant corporate sector add up to a control total. In Martin (2019), the control total was private sector gross fixed capital formation. Taking advantage of the resurrected PNFC data, the control total now becomes the gross fixed capital formation of the non-PNFC private sector. This mechanical process provides revised backcasts of the gross fixed capital formation of households and new backcasts of the gross fixed capital formation of financial corporations. As a result of the method of constructing the historic PNFC gross fixed capital formation data, the revised household sector series and new backcast financial corporations series are together less affected by the errors and weaknesses in the official aggregate data, notably before 1960. The impact of incorporating the resurrected PNFC capital account data, including those for changes in inventories, on the estimates derived in Martin (2019) of household and aggregate private corporate financial balances is material before 1960, but comparatively minor on average after 1960. Annex D provides further details.

The main challenge to this simple set of calculations is this: how can one be reassured that the resurrected corporate sub-sector data make any sense? The combination of the two methods of backcasting, one largely "top-down" reliant on identity manipulation of official series, the other "bottom up" reliant on adjusting out-of-date, often corrupted, archived datasets, risks incoherence. The resurrected financial corporations sector dataset may have become a statistical dustbin into which many data inconsistencies are unwittingly poured.

Testing the resurrected financial corporations data

The task that presents itself is to assess the resurrected financial corporations sector data for robustness. In the case of the PNFC dataset, reassurance was found in a comparison of the resurrected financial balance data with earlier vintages, notably the early-ESA95 series. Because the major revisions to the 2001 Blue Book data had offsetting effects across the capital account and "current" accounts (shorthand for the allocation of primary income, secondary distribution of income and, in principle, use of disposable income accounts), or offsetting effects within the current account, it was hypothesised that PNFC financial balance data of different vintages would be isomorphic representations of the same economic variable. The visual evidence (Chart 10) and formal tests (tables 4 and 5) did not reject this conjecture. The same hypothesis is not appropriate for financial corporations, however. The most important revision since the ESA95 accounts radically affects the record of "other investment income", part of property income. The impact is not offset elsewhere in the accounts of financial corporations, resulting in very large revisions to both the saving and the financial balance of financial corporations and to the corresponding series in the household sector.

To assess the robustness of resurrected financial corporations data it is therefore necessary to begin with the premise that financial corporations saving and financial balance, as represented in the ESA95 and ESA10 accounts, are not isomorphic representations of the same variable. The requirement instead is to explain the observed revisions, and in doing so establish whether the whole sequence of reconstructions of historic data, using top-down and bottom-up methods, adds up to a coherent whole.

Saving – broadly, the "undistributed profits" – of financial corporations is the focus of this assessment. The early-ESA95 datasets do not provide financial corporations data before 1987, save for series for gross operating surplus and the old calculation of FISIM. But it is possible, albeit with difficulty, to retrieve early-ESA95 financial corporations saving data, although not financial balance data, before 1987. The retrieval process for saving uses an across-sector identity, analogous to identity (1) for the private sector financial balance, and a simple within private sector adding-up identity, as follows:

$$S_v \equiv -\left(S_u + S_w + ERR\right) + X \qquad (8)$$
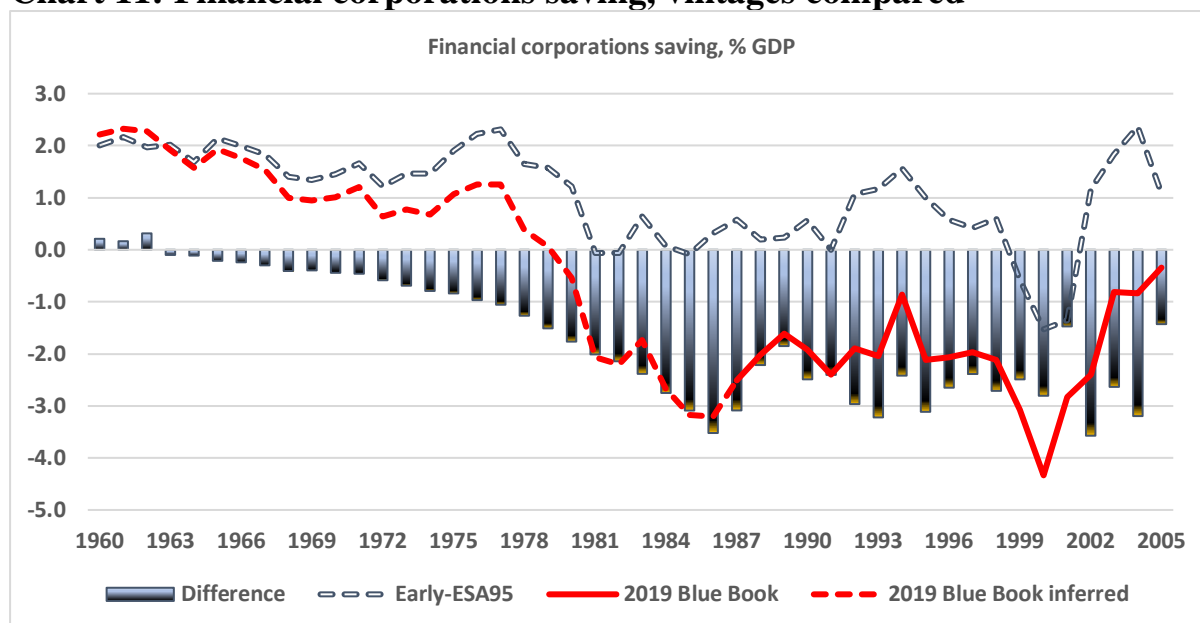
$$S_m \equiv S_v - S_h - S_n \qquad (9)$$

The across-sector saving identity (8) derives private sector saving from counterpart public sector saving and rest-of-the world saving (equal with reversed sign to the current account of the international balance of payments), the national accounts residual error, and economy-wide gross capital formation. The

derivation relies on private and public sector expressions equivalent to the capital account identity (6) that links saving and the financial balance, and the fact that sectors' net capital transfers and net acquisition of non-produced, non-financial assets each sum to zero across the economy. Identity (9) derives the saving of the financial corporations sector, denoted by the subscript "*m*", by deducting from the derived private sector total the savings of the household sector, denoted by the subscript "*h*", and of PNFC.

The difficulty of deriving saving estimates from the early-ESA95 datasets arises from the widespread corruption of the historic data before 1987. The public sector saving series (general government and public corporations) are frequently incorrect, partly as a result of the partial updating by public sector finances statisticians that, at the time, was not coordinated with revisions, if any, to other sectors. The 2001 Blue Book dataset, while offering, albeit after correction, the best available historic series for PNFC, is marred by large errors affecting GDP(I) relative to GDP(E) before 1963. This mistake was corrected in subsequent ESA95 datasets, but these were prone to other forms of data corruption. PNFC saving data were incorrectly overwritten, or lost. Annex A gives details. The consequence is that it is necessary to reconstruct the historic early-ESA95 financial corporations saving data from an amalgam of what are judged to be reliable sources, which include public sector finances data and different vintages of the early-ESA95 data. Details are given in the notes to Chart 11.

The chart displays the old and latest vintages of financial corporations saving data, under ESA95 and ESA10 accounting, and the differences between them. The sample period runs from 1960 to 2005, the dates corresponding to the span of usable data in the early-ESA95 datasets. The chart has two striking features. The first is the exceptional scale of the revisions to financial corporations saving. The second is the backwards decreasing nature of those revisions: moving from large (downward) revisions in the most recent years to much smaller, ultimately negligible, revisions by the early-1960s. The task is to uncover the driving forces that lie behind this unusual pattern.

Chart 11: Financial corporations saving, vintages compared

Financial corporations saving, % GDP

Legend: Difference · · · Early-ESA95 — 2019 Blue Book - - - 2019 Blue Book inferred

Sources and notes: "Early-ESA95" before 1987 :- (a) 2001 Blue Book for PNFC, (b) *UK Economic Accounts* published 4Q 2006 for a correction to 2001 Blue Book PNFC saving data before 1963 but, because of data corruption, not for PNFC saving from 1963, for the national accounts residual error, for the balance of payments current account and household sector saving data; (c) PSAT published 4Q 2006 for general government and public corporations saving; "Early-ESA95" from 1987 :– financial corporations saving from *UK Economic Accounts* published 4Q 2006; "2019 Blue Book inferred" - PSAT and *UK Economic Accounts* published 3Q 2019; PNFC data as derived here. Household saving is backcast before 1963. The missing observations on pension saving are backcast by maintaining it at its 1963 share of household income (for "early-ESA95") or by the method explained in Martin (2019).

For the period since 1987, the main driving force is known. The new ESA10 accounting standard for defined benefit (DB) pensions introduced in the 2014 Blue Book led to a major upward revision to the investment income that DB pension schemes, a sub-sector of the financial corporations sector, were recorded as paying to the schemes' members in the household sector. The resulting large fall in financial corporations saving was matched by an equivalent increase in household sector saving.

The detailed accounting is convoluted, but its principles are easily summarised. Under ESA95, the investment income received by households from pension schemes alone was measured by the actual receipts of dividends and interest earned from investing the schemes' assets. Under ESA10, there was no change to the principle of recording the actual investment income flow for one type of pension: funded workplace "defined contribution" (DC) schemes. But for funded DB schemes, there was a conceptual change: the actual flow of investment

income was replaced by a fictional flow of interest intended to capture each year the impact of the passage of time on the discounted present value of members' DB pension entitlements. DB entitlements increase for this reason – sometimes known as the "unwinding of the discount rate" effect - because the length of the future discounted period until retirement (and death) of the members shortens each year by one year. The fictional flow is equal to the product of the actuarial discount rate and the outstanding level of DB workplace pension entitlements, with a distinction made between schemes for whom government is held financially responsible and the remaining DB schemes sponsored by private corporations. The resulting revision to DB investment income represents the difference between the fictional flow of interest under ESA10 and the actual flow of investment income under ESA95. These DB pension-related income flows are not identifiable in the accounts but the scale of the revisions to them in the 2014 Blue Book can be gauged from contemporaneous revisions to financial corporations "other investment income".

The impact of the 2014 Blue Book changes on 1987 values of selected components of financial corporations sector accounts is recorded in a middle column of Table 7. Saving was revised down by 3¾ per cent of GDP as a result of the revision to other investment income, and it is clear from a comparison with contemporary ONS advisories that much the greater part would have come from the new treatment of DB pension schemes. As the table also shows, the 2014 Blue Book revision to other investment income in 1987 dominates in scale all other revisions, including those arising from the widening of the definition of gross fixed capital expenditure in the 2007 and 2014 Blue Books, which had a much larger impact on PNFC accounts, and from the insurance company specific changes introduced in the 2012 Blue Book. New FISIM introduced in the 2008 Blue Book had a large impact on the revised concept of net interest income. But with the deductible old FISIM measure gone and with other revisions taken into account, the value of financial corporations saving in 1987 was little changed. The revisions caused by the new method of measuring DB pensions are therefore the dominant driver of revisions to financial corporations – and households - saving observed in 1987, and, it is plausible to conjecture, before 1987 as well.

Table 7: Incremental annual revisions to financial corporations data, 1987 values

Annual & cumulative revisions per cent of latest GDP	Revision to 1987 values in previous year's accounts						2001 to 2019*
	2007	2008	2012	2014	2015	2018	
Gross operating surplus	0.1	0.1	0.1	0.4	0.0	0.0	0.7
Old FISIM (before 2008 BB)	0.0	2.5	na	na	na	na	2.5
Net property income	0.0	-2.5	0.0	-3.7	0.1	-0.1	-6.2
of which:							
Interest	0.0	-2.7	0.0	0.0	0.1	0.0	-2.6
Distributed income	0.0	0.4	0.0	0.0	0.0	0.0	0.4
Reinvested earnings on FDI	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other investment income	0.0	-0.1	0.0	-3.7	0.0	-0.1	-4.0
Taxes on income	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net other current transfers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saving	0.1	0.1	0.1	-3.3	0.1	-0.2	-3.1
Gross capital formation etc.	0.1	0.0	0.0	0.3	0.0	0.0	0.4
of which:							
Gross fixed capital formation	0.1	0.0	0.0	0.3	0.0	0.0	0.4
Financial balance	0.0	0.1	0.1	-3.6	0.1	-0.2	-3.4

Sources and Notes: see Table 3. "na": not applicable. Gross operating surplus is measured inclusive of the value of intermediation services indirectly measured (FISIM). Before the 2008 Blue Book ("2008 BB"), (old) FISIM was a deductible item within the primary income account. Beginning with the 2008 Blue Book and the new calculation of FISIM, the impact on primary income of not deducting old FISIM was offset by a revised treatment and downward revision to net interest income. There was in addition "a modest revision to the aggregate estimate of FISIM" (Meader and Tily, 2008). Other investment income comprises payments less receipts of (a) income attributable to insurance policy holders, (b) payments with respect to pension entitlements and (c) other investment income payable to collective investment fund shareholders. These three components were not separated out in ESA95 accounts. Not shown in the table are the secondary distribution of income account transactions in social contributions and benefits: the balance of social transactions, which adds to gross disposable

income, is equal under ESA10 to the "adjustment for the change in pension entitlements". The latter is deducted from gross disposable income in the use of disposable income account. Trivial pension saving adjustments were also scored to the rest-of-the world sector in the ESA95 accounts under the general heading "adjustment for the change in net equity of households in pension funds reserves". There were no revisions to 1987 values of financial corporation series between the 2001 Blue Book and the 2006 Blue Book, so the final column can be read as showing the cumulative revision to 1987 values measured from either the 2001 Blue Book or the early-ESA95 accounts, as defined in Chart 11.

A formal test of this conjecture faces two challenges, however. First, no official data exist for financial corporations other investment income under ESA95 and ESA10 accounting before 1987, so the scale and nature of the revisions cannot be directly observed. Second, official documentation of the historic revisions before 1987 (as opposed to those since 1997) is sparse. The explanation of the 2014 Blue Book recalculation of historic household saving data is limited, for example, in Davies et. al (2015) to the statement: "The pre-1997 estimates are linked to the 1997-onwards estimates and also take into account the increasing popularity of both newly introduced and other pension schemes." An additional complication comes from the fact that much of the pension data embedded in the sector accounts are not "true" actuarial data but artificial constructions. The ONS has only "a full set of actuarial accounts back to 2010" (ONS private correspondence, May 2019). It is unfortunately the case that, despite helpful private correspondence, the models used by the ONS artificially to construct earlier pension data remain unclear and are not detailed in otherwise compendious methodological advisories, such as those by Jones (2014) and Levy (2011, 2012, 2017, 2018a, 2018b).

Progress in assessing the impact in the historic period of the changed method of measuring DB pensions on financial corporations saving can nevertheless be made. Two ways are explored.
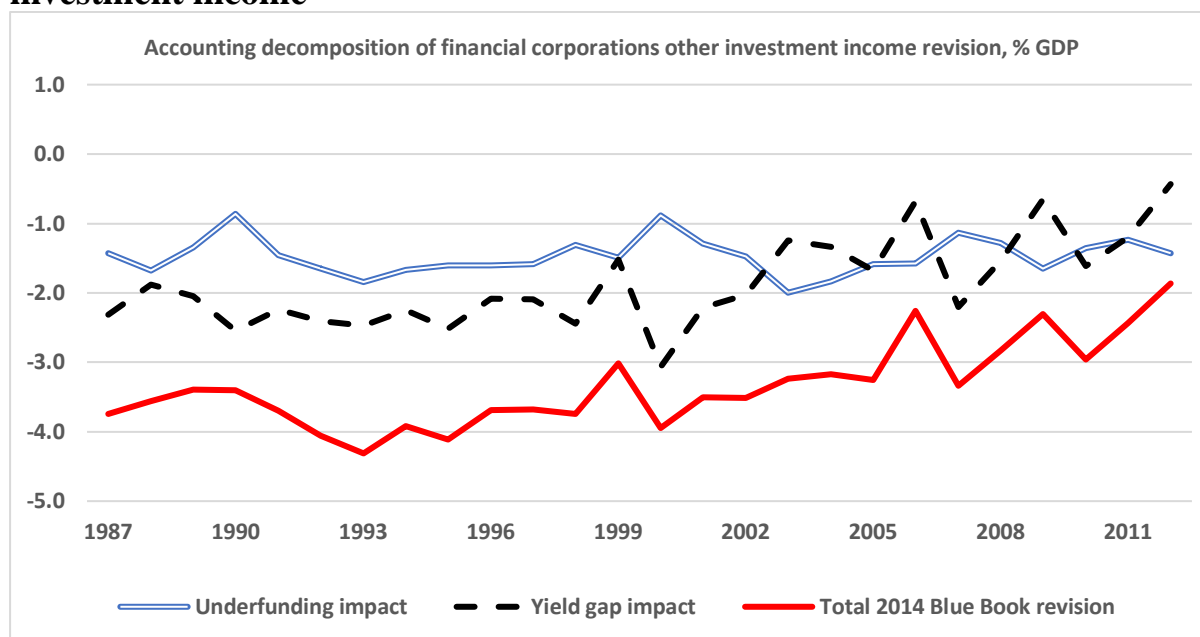
First, the 2014 Blue Book revisions to financial corporations other investment income can be decomposed by identity into two component parts and then backcast to 1960. Regarded as no more than best guesses, the backcast components nevertheless help to explain why the revisions to financial corporations other investment income and saving before 1987 would be backwards decreasing. The two parts of the accounting decomposition capture, first, the impact of the underfunding of DB schemes; and, second, the impact of the "yield gap": the excess of the actuarial discount rate used in the ESA10 calculations over the actual investment return on DB pension fund assets.

The rationale for the two impacts can be briefly described. The underfunding impact comes from the basic feature that distinguishes underfunded DB schemes from fully-funded DB schemes: an excess of actuarial liabilities over actual assets. This excess raises financial corporations investment income payments on DB *liabilities* – the ESA10 calculation - relative to the actual investment income derived from DB *assets* – the ESA95 calculation – and would do so even were yields on liabilities and assets the same. Such an impact was not possible under ESA95 accounting since it was interpreted by the ONS to imply that DB liabilities were equal to DB assets (Jones and Matthews, 2014, p3). The second impact reflects the fact that the actuarial discount rate, based on a long-term government bond yield for corporate-sponsored schemes, has exceeded the actual rate of return on DB assets, confined, under ESA95, to the schemes' receipts of

dividends and interest. Comparing the accounting under ESA10 and ESA95, the difference in yields has driven up the record of DB pension-related investment income payments made by financial corporations to households even for DB schemes that are fully funded. The yield gap impact has a more subtle interpretation. The impact can be regarded as a measure of the capital gains on DB pension fund assets that are implicitly added to household saving, and subtracted from financial corporations saving, under ESA10. Capital gains were not included in other investment income under ESA95 accounting. Capital gains are generally excluded from measures of income under both accounting standards. Further details are given in Annex E.

The second way to progress uses revisions to the official historic series for household pension saving to infer revisions before 1987 to financial corporations other investment income. In principle, the investment income debits of financial corporations that represent payments to households in respect of their DB and DC pensions should be included as credits in the historic household pension saving series. The household saving series should also include other items: as credits, the pension contributions, some fictional, of employers, and the actual pension contributions of employees, and, as debits, payments of pensions and the costs of running the schemes. Values for these components of household pension saving are not published before 1987, and may not, in fact, exist. How the ONS models its pension saving series for households before 1987 is not publicly documented. Nevertheless, progress with the current exercise is possible because the historic household saving series has been subjected to layered revisions by the ONS to incorporate accounting and other changes having an enduring past impact on the data (ONS private correspondence, May 2019). Moreover, if the observed large revisions in 1987 are a guide, the main cause of the revisions to the historic household pension saving data would likely come from the ESA10 revisions to other investment income. It follows that it is possible to infer revisions to financial corporations other investment income before 1987 from the concurrent revisions to historic household pension saving, and then to use the former to explain the backwards decreasing revisions to financial corporations saving.

Chart 12: 2014 Blue Book revision to financial corporations other investment income

Accounting decomposition of financial corporations other investment income revision, % GDP
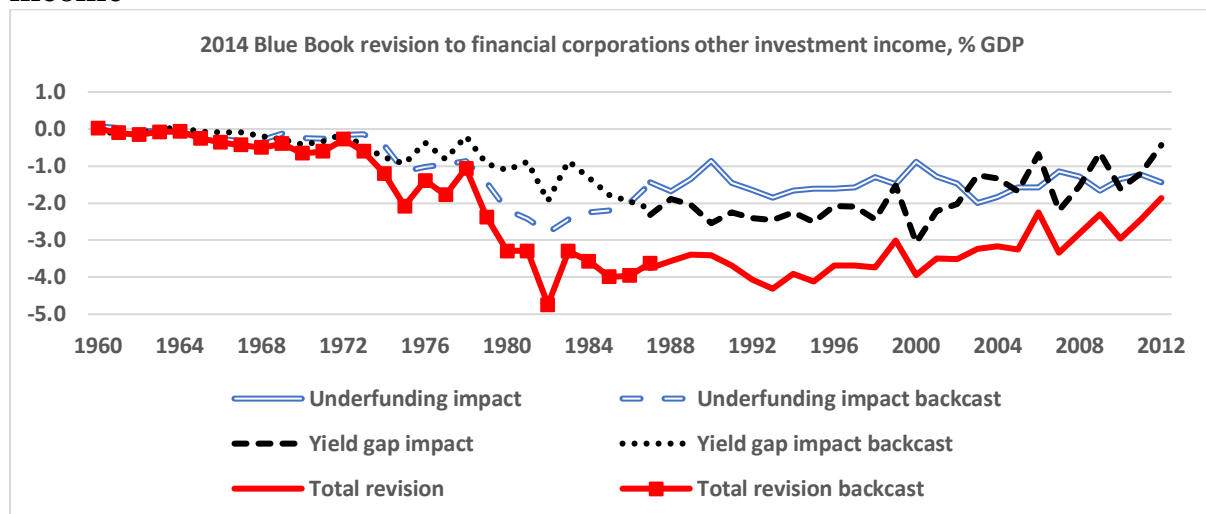

Sources and notes: See annex E.

Chart 12 begins the first way of decoding the revisions to financial corporations other investment income by dividing the 2014 Blue Book revisions in the 1987 to 2012 interval into the two impacts previously described: the first arising from the underfunding of DB pensions, the second arising from the gap between yields on DB pension fund liabilities and assets. The downward revision of the value of other investment income in 1987, worth 3¾ per cent of GDP, is decomposed into an underfunding impact – contributing a downward revision of 1½ per cent of GDP – and the yield gap impact – contributing a downward revision of 2¼ per cent of GDP. Over the whole period shown, the average downward revision to financial corporations other investment income is equivalent to 3¼ per cent of GDP, with 1½ percentage points coming from the underfunding impact and the remainder coming from the yield gap impact. It should be noted that the precise decomposition is not unique and is subject to the uncertainties of the underlying data. The important point is that it is necessary to have regard to both impacts, rather than to one or the other, to explain in an accounting sense why the 2014 Blue Book revisions to other investment income were so very large.

Chart 13 completes the first way of decoding the past by backcasting these two impacts to 1960. The data are rough and ready and certainly not sufficiently reliable to permit fine analysis. Treated as best guesses, the estimates are intended only as a guide to broad movements over time. The most important feature of the results is the backwards decreasing nature of the implied downward revision to financial corporations other investment income. The downward revision, worth 3¾ per cent of GDP in 1987, is very much smaller in the 1960s. The explanation of this history is consistent with the following somewhat speculative narrative.

First, pension funds were themselves a much smaller part of the economy in the 1960s. DB scheme members had on average fewer years of pensionable service, lived shorter lives and enjoyed benefits less generous that those offered by later schemes. Second, the excess of the discount rate applied to DB liabilities under ESA10 over the actual return on DB pension assets was smaller in the 1960s. Rough estimates put the yield gap at about 1 percentage point in the 1960s as compared with 4 percentage points in the 1980s. Third, it can be conjectured that, had ESA10-consistent actuarial standards applied in the past, DB schemes would have been found to have been generally underfunded, but that the degree of underfunding would have been much less marked in the 1960s. In reality, corporate sponsors' pension planning was undone by events. The liabilities of DB schemes rose unexpectedly over the decades because members lived longer than had been predicted and successive rounds of pension legislation added new safeguards. Accrued pension rights were indexed to inflation, funding standards were raised and underfunding rules tightened. What appeared affordable in the 1960s became, after the stock market crash in 2000, a major burden on corporate sponsors, who faced with levels of underfunding that they could not ignore withdrew or severely curtailed DB pensions, offering DC pensions in their stead.

Chart 13: Crude backcast of 2014 Blue Book revision to other investment income
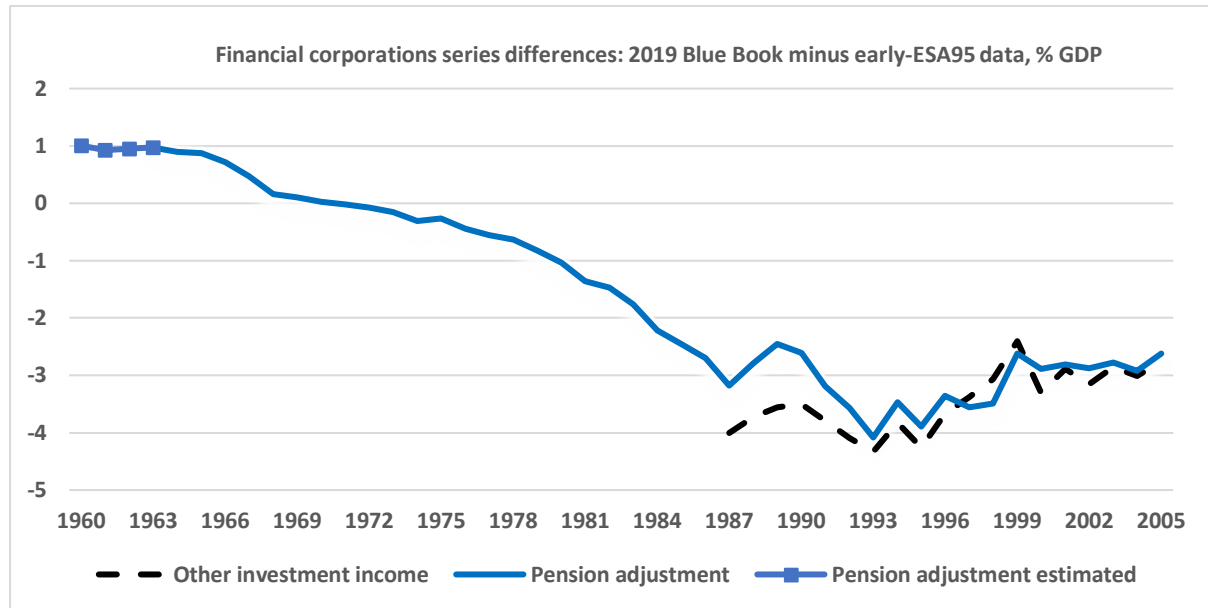

Sources and notes: See annex E. The small discontinuities in 1987 arise because of a change in the way the decompositions are very crudely constructed over the backcast period (1960 to 1986, with a 1987 overlap) and more precisely estimated over the period of observed revisions (1987 to 2012).

This analysis of the impact of the ESA10 valuation of DB pension schemes suggests why the unobserved revisions to financial corporations other investment income *should* be backwards decreasing. Attention now turns to what the ONS did in practice as a result of its layered revisions to the national accounts. In this second way to decode the past, the unobserved revisions to other investment income are inferred from the observed revisions to a related series: the adjustment

for the change in pension entitlements that appears in the accounts of financial corporations and households. The series for financial corporations begins in 1987 but can be equated with the household series that begins in 1963. The same series can be extended, after some mild estimation, to 1960. The inferred revisions to investment income can then be used to account for the changes in financial corporations saving data, shown in Chart 11, that have occurred since the early-ESA95 accounts.

Chart 14: Revisions to financial corporations pension adjustment and other investment income

Financial corporations series differences: 2019 Blue Book minus early-ESA95 data, % GDP

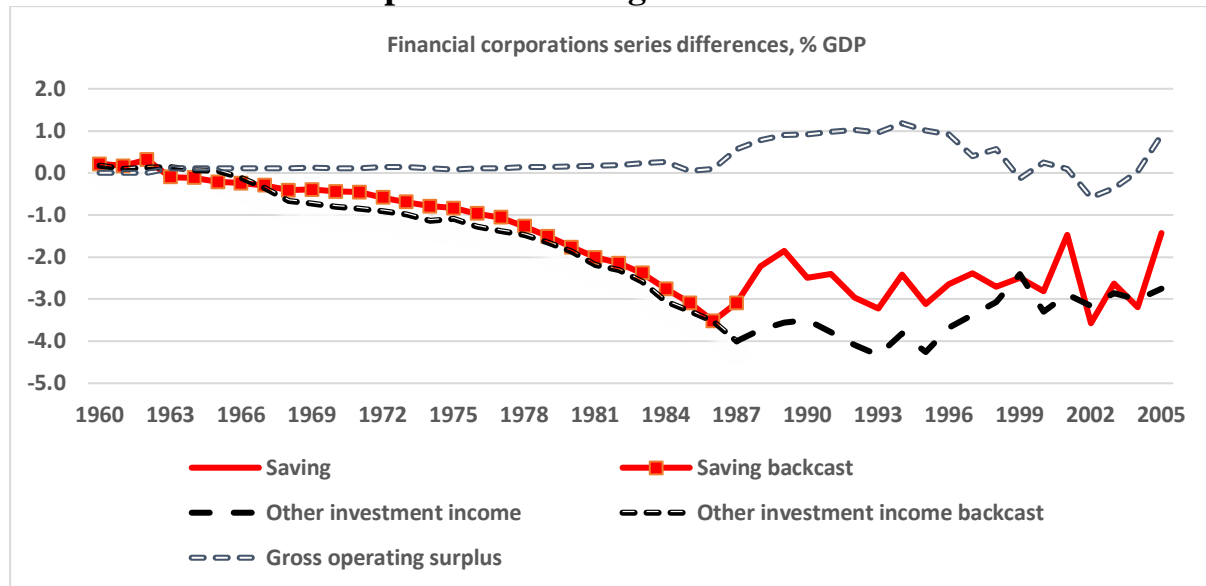Legend: Other investment income; Pension adjustment; Pension adjustment estimated

Sources: *UK Economic Accounts* published 4Q 2006 and 3Q 2019. Notes: The pension adjustment ("pension saving") is taken from the household accounts before 1987. The missing observations before 1963 are backcast by maintaining pension saving at its 1963 share of household income (for "early-ESA95") or by the method explained in Martin (2019). The revisions to financial corporations other investment income comprise the revisions at the time of the 2014 Blue Book and additionally those in the 2008 and 2018 Blue Books as recorded, for 1987 values, in Table 7.

Chart 14 begins this second way of decoding the past by comparing the revisions to the pension adjustment and to other investment income. Two features are striking. First, the revisions to the pension adjustment are strongly backwards decreasing, notably before 1987. The revisions before 1987 are less volatile than those after 1987, possibly a reflection of the ONS modelling techniques. Second, the revisions to the pension adjustment follow those to other investment income closely in the overlapping period beginning in 1987, although the difference between them is greater in the 1987 to 1990 interval than subsequently. The differences average ¼ per cent of GDP after 1990 but nearly 1 per cent of GDP

before 1990. It has not proven possible to explain the reasons for the greater difference in the early part of the overlapping period. Close examination of the data and contemporary ONS advisories suggest that a new method of measuring pension scheme costs introduced with the 2014 Blue Book may be responsible.

Chart 15: Financial corporations saving and related series differences

Financial corporations series differences, % GDP

Sources: See Charts 11 and 14. Notes: The series show the differences between the 2019 Blue Book data, backcast before 1987, and early-ESA95 data as a per cent share of 2019 Blue Book GDP. The differences in other investment income are backcast by aligning the series at the 1987 link year to the difference in financial corporations pension saving adjustment. The differences in gross operating surplus exclude the revisions in the 2008 Blue Books associated with the introduction of new FISIM. The impact of revisions to gross operating surplus due to revisions to the estimate of aggregate FISIM output were counterbalanced by the disappearance of the old FISIM, "the adjustment for financial services", and the replacement of actual net interest income flows with notional flows.

Chart 15 completes the second way of decoding the past by comparing the revision to financial corporations saving since the early-ESA95 accounts with the actual revisions, and a backcast estimate of the revisions, to other investment income. The backcast estimate is derived by applying a constant correction that has the effect of aligning the revision to the pension adjustment as a share of GDP with the revision to other investment income in 1987. It can be seen that the backcast measure of the revision to other investment income follows the revision to financial corporations saving over the historic period back to 1960. Complementing the earlier analysis of the possible impact of DB pension scheme underfunding and of the yield gap, the strong association seen in Chart 15 before 1987 supports the view that the backwards decreasing revision to financial corporations saving comes from the ESA10 change to DB pension accounting.

Unlike the data in Chart 13, those in Chart 15 are sufficiently reliable to permit a formal test of this proposition.

To do so, Chart 15 adds for consideration the revisions to financial corporations gross operating surplus as recorded, for 1987 values, in Table 7 but, in order to aid understanding of revisions to saving, net of revisions associated with the 2008 Blue Book implementation of new FISIM. It is noticeable that the revisions to gross operating surplus so adjusted move from negligible and broadly stable amounts before 1987 to positive amounts in the 1987 to 1998 interval. This shift coincides with the emergence of a gap between the revisions to saving and the revisions to other investment income. The chart suggests that the revisions to saving in the 1960 to 2005 interval might be explained, in an accounting sense, by the revisions both to other investment income and to gross operating surplus.

This hypothesis is formally tested in the regressions reported in Table 8. The dependent variable is the revision to financial corporations saving since the early-ESA95 accounts expressed as a per cent share of latest GDP. The two main regressors are the revisions to the data, similarly expressed, for other investment income, inferred before 1987, and for the adjusted measured of gross operating surplus. An intercept term is added.

Were these complete regressions of saving data that were directly constructed from all the component series, the fit would be exact, the parameters on all the regressors of all the components would be one and the intercept zero. But in this case, the saving data of financial corporations have been backwards inferred from the saving data of other sectors, and have not been built up by identity from the component series. The revisions since the early-ESA95 accounts capture all the resulting errors in the construction of the historic data as well as the differences that truly result from fundamental changes in accounting methodology and data sources. Nor is there available a full account of all revisions to all the components: if there were, the backcasting would have been unnecessary. Instead, the selection of regressors is limited to major revisions to those component series that are believed largely to account for the revisions to saving. These regressors are themselves measured imperfectly. It is therefore to be expected that the regressions would not fit perfectly with unit coefficients on the main regressors and a zero intercept. The extent to which the results approximate this ideal nevertheless helps one to determine whether the combination of top-down and bottom-up methods of data construction has succeeded in producing an historic dataset that makes sense.

Table 8: Regression results for revisions since early-ESA95 to financial corporations saving

Regression	Regressors					Regression statistics					
Spec.	*Con*	*OP*	Π	*DP*	*D01*	$\bar{R}^2$	Z1	Z2	Z3	Z4	Z5
Basic											
1: Coeff	-0.00	0.96	1.07			0.97	0.33	0.00	0.00		
1: t-statistic	-0.1	24.7	2.4								
2: Coeff	-0.01	0.91	0.97			0.94	0.0				
2: t-statistic	-0.2	24.8	7.2								
Extended											
Coeff	-0.01	0.96	1.05	0.52	1.00	0.97	0.06	0.19	0.25	0.16	0.59
t-statistic	-0.1	35.5	10.9	3.9	4.8						

Sources: see Charts 11 and 15. Notes: Dependent variable is the difference between the 2019 Blue Book, backcast before 1987, and early-ESA95 data for financial corporations saving as a per cent share of GDP. The sample period of annual observations is 1960 to 1987 for specification ("spec") 1; otherwise 1960 to 2005. Regressors: "*Con*" – constant term, *D01*- dummy variable taking a value of 1 in 2001, otherwise zero; other regressors are differences expressed as a per cent share of GDP between the 2019 Blue Book data, backcast as required, and early-ESA95 data for (a) net other investment income ("*OP*"), adjusted gross operating surplus ("Π"), net distributed income ("*DP*"). Before 1987, revisions to distributed income are set to zero. Regression statistics: $\bar{R}^2$ - coefficient of determination adjusted for degrees of freedom; Z1 – p-value for Jarque-Bera test for normality of regression residuals; Z2 – F-version of Breusch-Godfrey Lagrange Multiplier test for serial correlation; Z3 – F-version of White's test for heteroscedasticity; Z4 and Z5 – respectively, p-values of Wald tests (F-statistic) for the restrictions that the coefficients on *OP* and Π are equal to unity.

The results do not dash that hope. The regression fits are very tight, the estimated parameters on the key regressors are close to one and the intercept close to zero. This is the case in a basic regression estimated with the two main regressors over the period 1960 to 1987, in the same specification estimated over the maximal overlapping sample period 1960 to 2005, and in a third specification that produces regression residuals sufficiently well behaved to permit formal tests of the parameter estimates. These tests do not reject the proposition that the parameters on the revisions to other investment income and to gross operating surplus are each equal to one. The same is not found for an additional regressor measuring revisions to distributed corporate net income, but there are no data for this variable before 1987 which is instead backfilled with zero values. The conclusion is that the resurrected saving data of financial corporations, and, by extension, of PNFC, households and the private sector appear to form a coherent whole, with no large statistical dustbin blighting the dataset.

5) Summary and conclusions

This paper develops what is believed to be a novel method of resurrecting UK national accounts corporate sector data before 1987, the date prior to which fully comprehensive sectoral data are not provided by the Office for National Statistics. A distinction is drawn between the sectors comprising private non-financial corporations, on the one hand, and financial corporations, which include some state-controlled enterprises, on the other hand. Save for some categories of property income, the resurrected PNFC dataset runs in detail from 1960. Limited by the absence of historic official data for components of household disposable income, the financial corporations dataset before 1987 is confined to official data for gross operating surplus and the resurrected series from 1960 for reinvested earnings on foreign direct investment, saving (broadly speaking, "undistributed profits") and items on capital account, including the financial surplus. Exceptionally, resurrected capital spending data for both corporate sectors run back to 1946.

The method of data reconstruction relies on archived, out-of-date, too frequently unreliable national accounts datasets, the scrutiny of those data to remove mistakes, and a detailed examination of a subset of an otherwise overwhelming number of national accounts revisions confined to those having a material and enduring impact in the historic period before 1987. Observed revisions to PNFC gross operating surplus were used to infer the assumed balanced but unobserved revisions to two series: (a) net interest income, associated with the introduction in the 2008 Blue Book of a new method of measuring indirectly the otherwise unpriced financial services of banks and other financial institutions, and (b) gross fixed capital formation, resulting from revised estimates of intangibles, notably R&D, and other changes in the 2007 and 2014 Blue Books. The resulting PNFC

financial balance data were little changed from those that appeared in archived national accounts that conform to the discontinued European accounting standard, ESA95. The same is not true, however, of the financial balance data for financial corporations. Large revisions arose as a result of the new method of measuring defined benefit pension schemes under the new accounting standard, ESA10, introduced in the 2014 Blue Book. The impact of the new pension methodology received close consideration. The analysis highlighted the likely nature of the resulting revisions to other investment income before 1987, which matched the scale and nature of historic revisions to financial corporations saving.

Robustness tests suggest the resurrected data for the saving of the two corporate sub-sectors are a plausible fit with official historic estimates of household saving and estimates of private sector saving derived by the "top-down" method explained in Martin (2019). Comparable tests of the coherence of sectors' financial balance data are not possible, but the hypothesis that different vintages of PNFC financial balance data are isomorphic representations of the same economic variable is not rejected.

The nature of the underlying data and the backcasting methods means that there is no reason to change the subjective reliability ratings offered in Martin (2019): a "D" rating for saving and a lower rating for financial balances. Attention is again drawn to the weaknesses in the official data, notably the problems with the historic estimates of gross fixed capital formation before 1960 and the inconsistences with the national accounts that mar the otherwise invaluable ONS national accounts consistent public sector finances dataset before 1987. Problems suspected of affecting official data for private sector capital transfers before 1954 have yet to be examined and resolved. Deficiencies also arise from the mechanical methods used here to backcast the capital spending of households and financial corporations. Additional errors in the resurrected PNFC dataset may come from the way in which unobserved revisions to gross fixed capital formation were inferred from observed revisions to gross operating surplus. However, this same method may have improved the reliability of estimates for the capital spending of households. Compared with the capital account estimates presented in Martin (2019), the revised method of backcasting used here, incorporating new sources and methods, has a material impact before 1960 but a small impact, on average, thereafter.
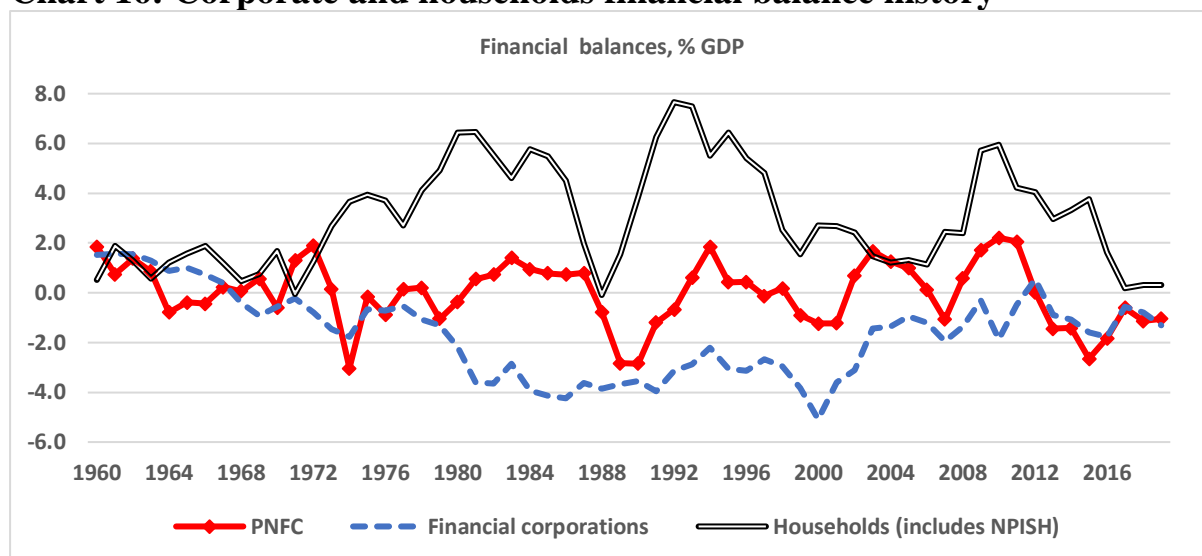
Remaining data tasks are further to scrutinise the resurrected dataset for robustness and to take on board the impact of forthcoming 2020 Blue Book revisions. Once further analysis is complete, it is the intention to make the resurrected historic sector dataset publicly available. Other researchers will then be in a position to assess the quality of this dataset against any others that may be derived using different methods. Line-by-line scrutiny may be facilitated by the forthcoming release, noted in Chadha et al. (2019), of a pre-ESA95 dataset

reconstructed by Anne Harrison, the editor of the internationally agreed 2008 System of National Accounts on which ESA10 is based.

Beyond historic data reconstruction, a future research agenda could include this list: (a) the challenges to the ESA10 measurement of pension saving: Durant et al. (2015) detail the way the Bureau of Economic Analysis, the US statistical agency, departs from the ESA10 manual; (b) the correct way to conceptualise the relationship between defined benefit pensions and corporate saving: a longstanding question raised, for example, by Poterba (1987); (c) a re-examination of the contention that PNFC were running aberrantly high financial surpluses in the 2000s: a topic explored, for example, by Gruber and Kamin (2016) and Dao and Maggi (2018); (d) an exploration of the notion of a general "savings glut": a vast subject recently addressed by Mian et al. (2020); and (e) the level of sector disaggregation best suited to an understanding of the drivers of the economy's aggregate demand. Godley (1999, appendix 1) expressed a strong preference on empirical grounds for a focus on private sector behaviour, whereas his last co-authored theoretical work promoted the separate treatment of "households and production firms … an essential distinction" (Godley and Lavoie, 2009, p25).
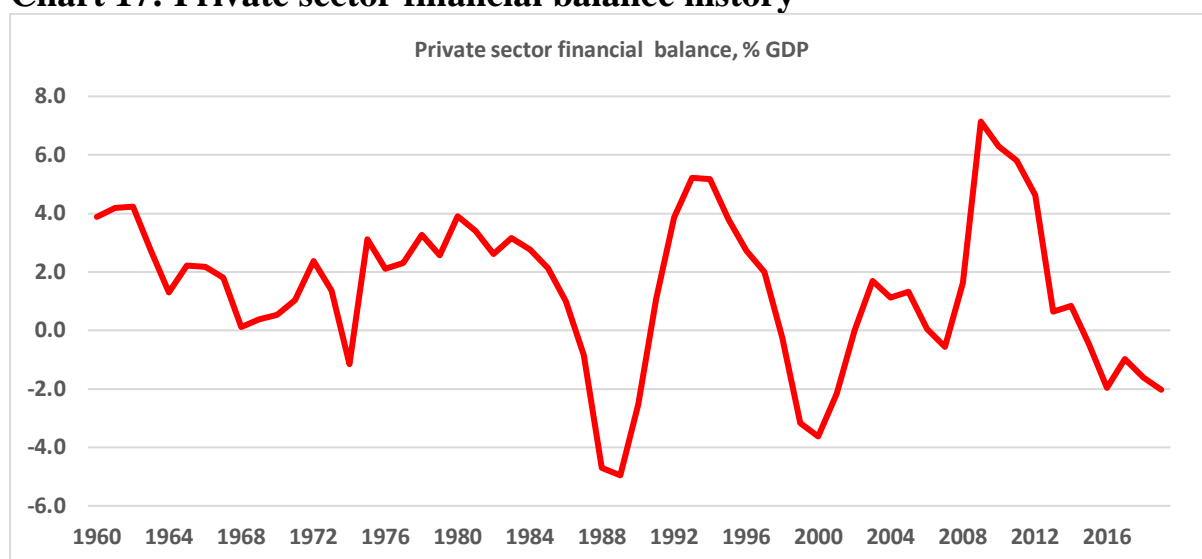
The resurrected financial balances depicted in Charts 16 and 17 offer a glimpse of the issues. Over a sixty-year period, the financial balance of the private sector appears to revert to an average level, albeit at varying speeds. The same is true of the PNFC financial balance. But formal tests do not firmly reject the notion that the financial balances of financial corporations and of households are non-stationary. Should researchers take advantage of the apparently stationary properties and less error-prone estimates of the private sector financial balance or seek to explain the different behaviours of the constituent sub-sectors? All such matters will repay future investigation.

Chart 16: Corporate and households financial balance history

Financial balances, % GDP

Sources: *UK Economic Accounts* published first quarter 2020, my calculations.

Chart 17: Private sector financial balance history

Private sector financial balance, % GDP

Sources: *UK Economic Accounts* published first quarter 2020, my calculations.

Note: The majority of the data used in this paper are taken from the electronic datasets published by the ONS with each release of the main national accounts publications: The Blue Book and the UK Economic Accounts. The cut-off date for ONS information in this paper is March 2020.

Annex A: Archived national accounts sources of historic corporate data

This annex describes past vintages – pre-ESA95 and early-ESA95 - of corporate sector data, including evidence of data corruption and identity breaches. Consideration is given to the choice of archived dataset from which PNFC data might be best reconstructed.

Pre-ESA95

The full *pre-ESA95 corporate sector dataset* begins in 1960, a date that hails from the separation of the accounts of financial companies, on the one hand, and of industrial and commercial companies, on the other hand, that appeared for the first time in the 1964 Blue Book. This edition of the UK *National Income and Expenditure* publication (the former title of the UK *National Accounts*) presented the sub-sectors' appropriation accounts (including profits, dividend and interest paid and received, taxes and net profits from abroad) back to 1953, but it was reported that data were not available to take back the capital account items before 1959.

The last available (1998) vintage of the pre-ESA95 dataset is largely coherent, at least from 1960, although some minor adjustments are required in the 1960 to 1962 interval to ensure summation to the corporate totals of the sub-sector ICC and financial companies series for gross trading profits and undistributed profits. The small additive adjustments are applied to the series for financial companies. ICC current transfer payments – a trivial item during this interval - are inferred by identity from ICC profits, taxes, property income and saving. Exceptionally, pre-ESA95 series for the financial surplus of private corporations, in total and for the two corporate sub-sectors, run back to 1948, but these series come without the data for saving and capital account items that would enable checks for accounting consistency.

Early-ESA95

    (a) 1998 Blue Book

The *1998 Blue Book* vintage of the *early-ESA95 dataset* included a comprehensive set of data for the PNFC sector before 1987, the result of a one-off ONS exercise undertaken during the ESA95 conversion (ONS private correspondence, 1999). The PNFC data are internally coherent – satisfying own-sector accounting identities - from 1960, the starting date of series for saving and the financial balance. Some data, notably those for the gross operating surplus, gross capital formation and net property income, run back to 1948. However, it is not possible to verify the reliability of the property income series: key components, including payments of interest and dividends, are absent before 1984. The historic series is also subject to an apparent cliff edge: the recorded property income deficit doubles between 1959 and 1960.

With the exceptions of the gross operating surplus and the related adjustment for "Financial Intermediation Services Indirectly Measured" (FISIM), the financial corporations sector is not articulated before 1987, although it is possible to infer financial corporations saving before 1987 from economy-wide identity relationships.

(b) 2001 Blue Book

The *2001 Blue Book* vintage of the *early-ESA95 dataset* incorporated comprehensive revisions running back to 1948. Of relevance to the corporate sector, the ONS downwardly revised the "proportion of income allocated to partnerships within the non-financial corporations sector" (2001 Blue Book, p34). This revision affected the record of PNFC gross operating surplus, which, following the conversion to ESA95, includes the self-employment income - the sum of the not-separately-identified profits and compensation of employees - of partnerships previously counted as part of the former "personal" sector. A comparison of the 1998 and 2001 ESA95 dataset vintages reveals that the revision to self-employment income (now called "mixed income") was taken back to 1959, but not before. Other component items were unchanged before 1987; in particular, there was no change to the series, available back to 1984, for corporate dividend distribution, which includes partnership "dividends" (formally known as the "withdrawal of income of quasi-corporations"). Granted these revisions and non-revisions, the 2001 Blue Book is correct in recording a downward revision to PNFC saving before 1987. However, the record of the financial surplus was not correctly amended: it was generally revised *up* each year by the same absolute amounts as PNFC saving was correctly revised *down*. A corrected financial balance series before 1987 can be easily derived from the published data so that it conforms to the revised series for PNFC saving.

There is evidence of other data corruption in the 2001 *Blue Book*. The overwriting of series, one of the problems of ONS database management noted in Martin (2007), is seen in the in-filling before 1987 of the financial balances of households and financial corporations with the series for public corporations. More problematic is evidence of errors in the core GDP accounts. Before 1965, the GDP expenditure and GDP income statistical discrepancies that measure the respective gaps between headline GDP, on the one hand, and GDP(E) and GDP(I), on the other hand, and the related national accounts residual error, do not square with the series for GDP(E) and GDP(I) which can be calculated directly from the expenditure and income component data. In excess of 1 per cent of GDP, the inconsistencies in the 1960 to 1962 interval are notably large, the result of errors of unknown cause affecting the income statistical discrepancy. In 1962, whereas the published income statistical discrepancy puts GDP(I) £23 million *above* headline GDP, the measure of GDP(I) calculated directly from the income component data is £373 million *below* GDP. On this reckoning, the values before

1963 of some or all of the income components of GDP in the 2001 Blue Book dataset were too low.

(c) Last Blue Book and UK Economic Accounts before 2007 ONS data purge

The 2006 Blue Book and the edition of *UK Economic Accounts* published in the second quarter of 2007 were the last of the early-ESA95 datasets to provide a number of PNFC series before 1987. Some were useful additions to those previously available, including a long run of data for PNFC reinvested earnings on foreign direct investment (FDI). However, data corruption had become widespread. The PNFC saving series before 1987 was the same as that published in the 1998 Blue Book, and so did not reflect the 2001 Blue Book revisions to gross operating surplus which were correctly retained in the historic period after 1963. The PNFC saving identity was therefore breached before 1987. Oddly, the PNFC saving data dropped out altogether before 1965.

On the positive side, the ONS had by this time addressed the discrepancies that affected the core GDP series in the 2001 Blue Book. Before 1963, GDP(I) had been materially revised up relative to GDP(E) with a consequential downward revision to the national accounts residual error averaging 2 per cent of GDP over the full period before 1963 and 3½ per cent of GDP in the 1960 to 1962 interval. Most of the GDP(I) revision was associated with a large upward revision to the gross operating surplus of households, but PNFC operating surplus was also materially affected, revised up by 1½ per cent of GDP in the 1960 to 1962 interval. The revisions are not documented in the Blue Book publications.

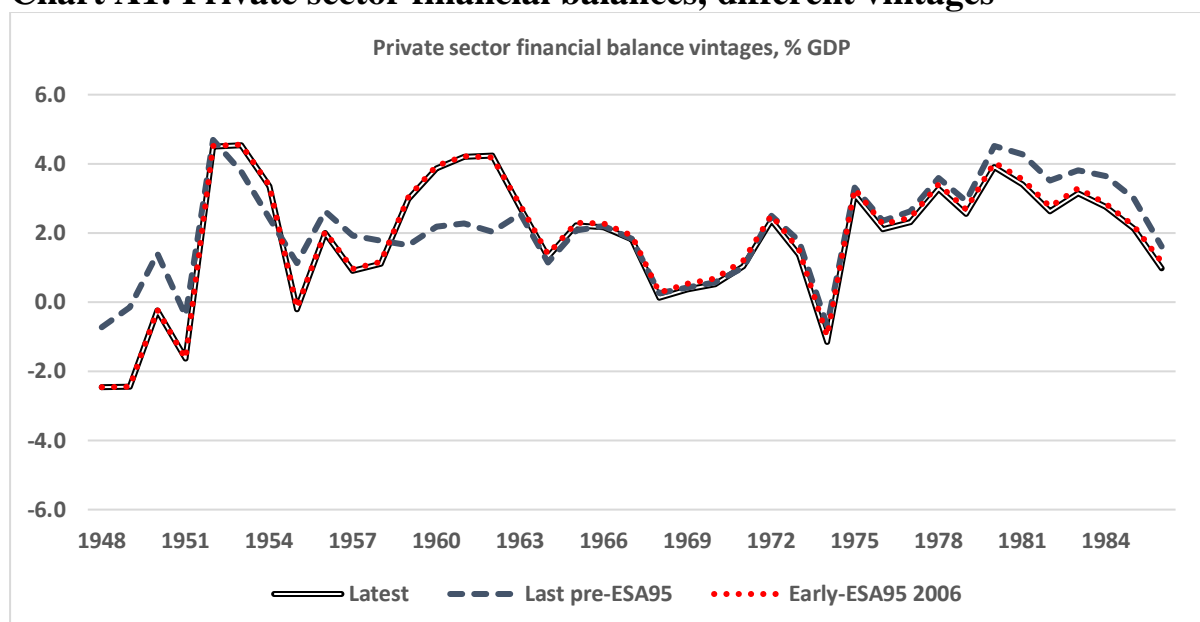*Selecting between pre-ESA95 and early-ESA95 datasets*

As noted in the introduction to the main text, estimation errors may arise from the unavoidable mixing together of different methods of backcasting: *method one* using identity manipulation and the combination of best available latest sources as in Martin (2019); *method two* using adjusted archived datasets. The risk of inadvertently creating such errors can be mitigated by careful selection of dataset vintage. It is a requirement that the PNFC data resurrected using the second method are a subset, allowing for minor random error, of the private sector data resurrected using the first method. This requirement can be simply tested by examining different vintages of the private sector financial balance. Significant differences for this variable between the latest data, on the one hand, and each earlier vintage, on the other hand, would be indicative of incompatibility that would invalidate the mixing of PNFC data resurrected by method two with private sector data resurrected by method one.

Two past dataset vintages are considered: (a) the last pre-ESA95 dataset published in the *UK Economic Accounts* in early-1998 and (b) the early-ESA95 vintage data constructed from the public sector finances analytical tables (PSAT) and *UK Economic Accounts* published in the final quarter of 2006. The latter

dataset contains the large upward revisions before 1963 to the GDP(I) and PNFC gross operating surplus data presented in the 2001 Blue Book. The differences across datasets in the private sector financial balance series can be additionally linked to differences in the financial balances of the other main institutional sectors – general government, public corporations and the rest of the world - and to differences in the national accounts residual error. An accounting identity analogous to identity (1) in the main text formalises the link. Comparisons of counterpart balances and the national accounts residual error can be useful as a means to trace the proximate causes of differences in the vintages of the private sector financial balance.

Further comparisons with other series can be envisaged, but those examined here for financial balances are sufficient to reject use of the pre-ESA95 dataset to backfill the missing PNFC history.

Chart A1: Private sector financial balances, different vintages

Sources*: UK Economic Accounts* published 2Q 1998, 4Q 2006 and 4Q 2019; PSAT published 4Q 2006 and 4Q 2019. Notes: Latest and early-ESA95 2006 data for private sector financial balances and the national accounts residual error are derived from a combination of national accounts, PSAT and balance of payments data as described in Martin (2019) and the main text. Pre-ESA95 data are from the national accounts alone. The private sector includes state-controlled financial corporations.

Chart A1 compares the different vintages of the private sector financial balances each expressed as per cent share of the latest vintage of GDP data. It is immediately apparent that the pre-ESA95 vintage series strongly departs from the latest series in individual years before the early-1960s and, to a lesser extent, after the 1970s. The differences are both positive and negative in the period before the early-1960s, and average out to such an extent that the null hypothesis of equality

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of means of the two vintages over that sub-period is not rejected by standard tests. However, there is clear visual evidence of at least one break in the statistical behaviour of the differences between the latest data and the pre-ESA95 data. By contrasts, the early-ESA95 vintage private sector financial balance series much more closely replicates the latest vintage over the entire historic period.

A formal test of the presence of breaks in the behaviour of the series differences is possible using the Bai-Perron (1998, 2003) procedure, albeit with the recognition discussed, for example, in Antoshin et al. (2008), that in small samples the test results are especially vulnerable, depending on specification and the behaviour of the disturbances, to either outsized type one or type two errors.
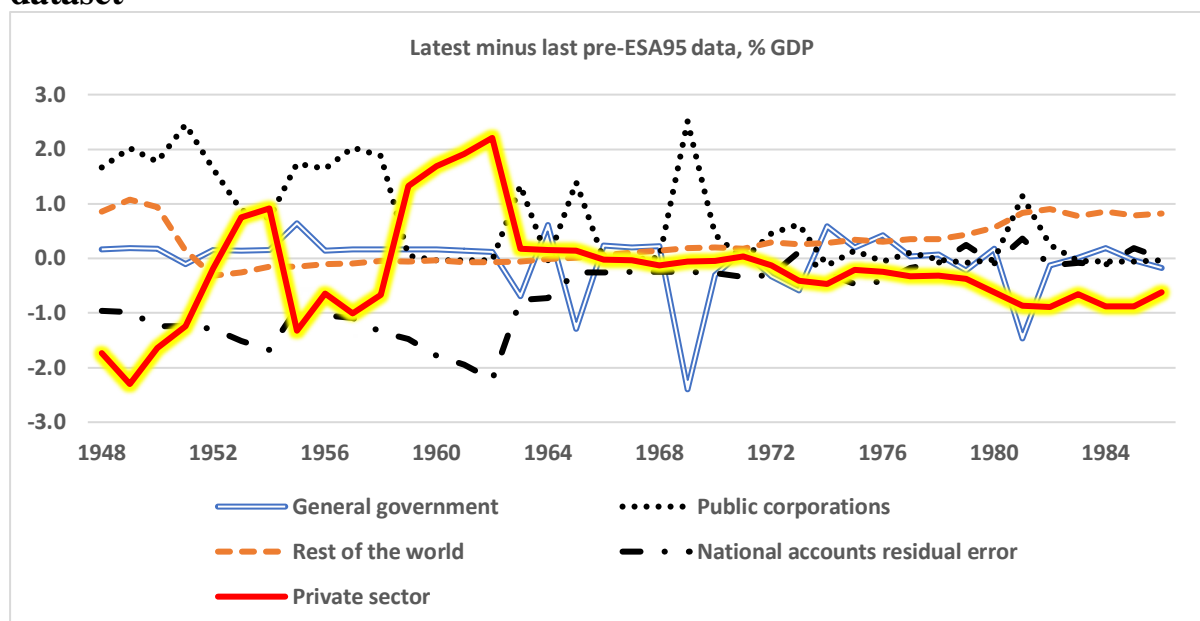
Table A1: Break tests of private sector differences, latest versus earlier vintages

Difference, % GDP	Year at the beginning of the period after the break
Compared with pre-ESA95	1954, 1959, 1964
Compared with early-ESA95	none

Sources: See Chart A1. Notes: Results of testing for structural breaks in the autoregressive parameter at multiple unknown break dates in an intercept plus first-order autoregressive representation of the difference between the latest and earlier vintage data for the private sector financial balance. The sample period is 1949 to 1986. Based on evidence of heteroscedasticity in the full sample, the regressions are estimated using Huber-White-Hinkley heteroscedasticity consistent standard errors and covariance. The global breaks versus no break testing procedure of Bai and Perron (1998) is performed using the default settings in the software program Eviews® 11. The intercept term is not statistically significant in the full sample regressions and not allowed to break, thus conserving already limited degrees of freedom. The tabulated years are the breakpoint years selected in common at the 5% level of significance – the critical values are asymptotically derived in Bai and Perron (2003) - by the double maximum tests, "UDmax" and "WDmax". The tests are of the null hypothesis of no structural break against the alternative of an unknown number of breaks up to the default maximum of five. Perron (2006) states that the double maximum tests are "the most useful tests to apply when trying to determine if structural changes are present."

The results selected are shown in Table A1, which reports three breaks in the series comparison with the pre-ESA95 vintage data. Two breaks are identified as occurring before 1959; the third break differentiates the period up to and including 1963 from the subsequent period. The same procedure applied to the differences between the latest and early-ESA95 vintages of the private sector financial balance uncovers no breaks in statistical behaviour.

Chart A2: Aggregate financial balance changes since the last pre-ESA95 dataset

Latest minus last pre-ESA95 data, % GDP

Legend:
- General government
- Public corporations
- Rest of the world
- National accounts residual error
- Private sector

Sources: *UK Economic Accounts* published 2Q 1998 and 4Q 2019; PSAT published 4Q 2019. Notes: See Chart A1 notes.

Charts A2 and A3, drawn with the same vertical scale, show the counterparts to the private sector financial balance differences for each past vintage compared with the latest vintage. The striking feature of the charts are the very large differences affecting at different times all counterpart series in the comparison with the pre-ESA95 data and the absence of any similarly large differences in the comparison with the early-ESA95 data. This finding further supports the decision not to use the pre-ESA95 dataset for the purposes of resurrecting the PNFC and financial corporations accounts.

There are other points of note regarding the pre-ESA95 dataset differences. Contrary to what one might expect were these normal revisions, the differences are typically larger in the period before the early-1960s. Were the revisions normal, larger differences might be expected to occur later, rather than earlier, in the overlapping period. This finding is in keeping with the wider set of comparisons, albeit with different sub-periods, drawn in Martin (2007). It was there observed that "absolute differences between the datasets are often larger in the earlier sub-period …".

Also of note is the behaviour of the national accounts residual error, which follows before 1963 a markedly different course in the pre-ESA95 vintage data compared with the latest vintage. The Bai-Perron procedure used in Table A1 identifies two breaks in the differences between the two vintages, one for the period ending 1955, the other for the period ending 1962. No such breaking

behaviour appears in the early-ESA95 data comparison: the differences in every year before balancing techniques eliminated the national accounts residual error are typically zero or vanishingly small.

Chart A3: Aggregate financial balance changes since early-ESA95 dataset, 2006.

Sources*: UK Economic Accounts* and PSAT published 4Q 2006 and 4Q 2019. Notes: See Chart A1 notes. The "General government unadjusted" series shows the impact of *not* retrospectively applying to the 2006 vintage data the downward revisions enacted in September 2014 to the general government financial deficit in the 1973 to 1978 interval. The revisions were presented in the regular PSAT tables but, to this day, not in the national accounts consistent PSAT tables. The revisions reduced the general government financial deficit by an average of less than ¼ per cent of GDP, with a maximum equivalent to ½ per cent of GDP in 1974. The annual revisions are of the same absolute magnitude as the changes to the ONS record of UK contributions to the European Union (EU); specifically, value added tax and gross national income-based contributions. According to ONS advisories (Gittins, 2013 and 2014), changes introduced under ESA10 to the recording of the UK's contributions to the EU were presentational and had no impact on the recorded financial balance. No explanation for the financial balance revisions in the 1973 to 1978 interval has been found.

The reasons for the abnormal timing of the differences between the current vintage and the pre-ESA95 national accounts and the strikingly odd behaviour of the national accounts residual error are unknown. It is possible that they have a common origin: the preparatory exercise that the ONS undertook to improve the integrity of the pre-ESA95 accounts in the transition to ESA95. Brueton and Thorpe (1998) explain:

"The preparatory work for implementing ESA95 required a thorough scrutiny of present National Accounts methodology, which identified areas where there was scope for improvements. The ONS therefore took the opportunity to put through extensive long-run revisions this year to improve the accounts and provide a sound basis for the transition to ESA95. These revisions have produced a more coherent set of accounts and reduced the need for balancing adjustments overall: a major quality improvement."

It appears that the revisions since the pre-ESA95 accounts may well conflate two broad sources of revision: those due to ESA95 and ESA10 accounting and related changes and those due to the undocumented ONS "quality improvement" of the pre-ESA95 accounts.

Annex B: Root cause analysis of revisions shown in main text Table 3

This annex details the causes of material revisions to the 1987 values of PNFC series presented in the 2001 Blue Book. A general guide to national accounts sources and methods is not offered; technical guidance can be found in many published ONS advisories and in the articles cited below. The analysis is conducted from the perspective of the PNFC sector alone under several headings: FISIM, capitalisation and layering, pensions, and other miscellaneous items.

a) New FISIM

The new FISIM method introduced with the 2008 Blue Book had, in principle, no impact on PNFC saving or on the financial balance. The same was true for all other sectors. In the case of PNFC, the changes were confined, on the expenditure side, to the record of PNFC purchases ("intermediate consumption") of the imputed services of financial intermediaries ("banks", for short) and, on the income side, to PNFC gross operating surplus and, within property income, to net interest income. In theory, albeit not, it turned out, quite in practice, the downward revision to PNFC gross operating surplus should have matched the upward revision to PNFC net interest income (interest receipts less interest payments), leaving PNFC saving and the financial balance unchanged.

The reduction in PNFC gross operating surplus arose from the newly accounted for addition to their costs of production represented by PNFC purchases of banks' imputed services. The additional costs in the production account reduced PNFC value added, with a resulting equal reduction in gross operating surplus. Offsetting the reduction in the operating surplus was a boost to PNFC primary incomes arising from a reduction in measured net interest payments. These appear in Table 3 as an upward revision to net interest income. The meaning of these interest flows was, however, radically altered. In place of the actual interest receipts and interest payments that had previously appeared in the accounts, the new FISIM method substituted hypothetical flows calculated using a "reference" rate of interest. In theory, the reference rate, purportedly the cost to the banks of borrowing funds, lay between the higher rates of interest charged by banks on their loans and the lower rates of interest paid by banks on their deposits. The differences between the actual and hypothetical flows of interest receipts and interest payments become, when suitably combined, the new measure of the value of banks' imputed services that, elsewhere in the accounting, depresses PNFC operating surplus.

The aim of the new FISIM was to apportion to the different sectors of the economy the cost of purchasing the imputed services of banks. Prior to the 2008 Blue Book innovation, the imputed services were measured without apportionment and were equated, broadly speaking, to the difference between banks' interest receipts and payments. The difference, typically a positive sum

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reflecting the spread between banks' loan rates and deposit rates, was included under ESA95 in the record of financial corporations gross operating surplus. Old FISIM was also calculated as part of pre-ESA95 accounting, but not always so clearly recorded. In the 1997 Blue Book (Table 5.4), for example, old FISIM – the formal pre-ESA95 term was "the adjustment for financial services" - was netted off the gross trading profits of financial companies, producing negative entries. However presented, old FISIM had no impact on the level of GDP, interest flows being treated as transfers within the national accounts. New FISIM, by contrast, raises GDP in so far as there is an associated increase in final consumption and in exports after accounting for imports.

This greatly simplified description of the new FISIM calculation does not explain why 1987 values of PNFC saving and financial balance shown in Table 3 were revised up in the 2008 Blue Book: the downward revision to gross operating surplus is somewhat less than the upward revision to PNFC net interest income. Although the impact is small, it is necessary to understand its origin in order to weigh the implications, if any, for the PNFC accounts history before 1987. As the non-zero impact in 1987 lies outside the reported scope of Blue Book revisions due to the annual benchmarking and balancing exercise, the explanation probably lies elsewhere. Contemporary official documentation does not shed much light. The puzzle is not anticipated by Akritidis (2007) in his methodological paper written in advance of the 2008 Blue Book. Two ONS statisticians reviewing the 2008 Blue Book revisions note the impact of a modest revision to aggregate FISIM on financial corporations data but add that the sector allocation of FISIM should have had no impact on the financial balances of other sectors (Meader and Tily, 2008, p 41). The authors add the rider (my emphasis): "in theory (*though not exactly in practice*)". The exposition by Collinane (2010) sets out the theoretical position that FISIM does not affect the financial balance. Nor is any clue to be found in later documentation describing the 2014 Blue Book FISIM changes (which had no impact on PNFC net interest payments before 1997) or the complex measurement problems that distorted FISIM calculations during the global banking crisis (Grovell and Wisniewski, 2014; Akritidis and Francis, 2017). It may be conjectured that the downward revision in the 2008 Blue Book to the 1987 value of PNFC gross operating surplus was too small, the result of a misallocation between sectors of the intermediate consumption of banks' imputed services or faulty balancing adjustments. An error related to new FISIM calculations uncovered during the 2016 Blue Book round led to a downward revision of PNFC gross operating surplus (Davies, 2016, p25).

It is concluded that the 2001 Blue Book record of saving and financial balance before 1987 should remain unaffected by the backcasting of new FISIM but that some allowance should be made for the discrepancy between the official estimates of FISIM and the revision to net interest income in 1987.

b) Capitalisation, layering and gross fixed capital formation

Two major causes of the large upward revisions to PNFC gross operating surplus, saving and gross fixed capital formation are capitalisation and layering. Capitalisation refers to the national accounts procedure of reclassifying as capital spending selected items of expenditure that were previously counted as "intermediate consumption": for corporations, their "consumption" of – or spending on - overheads and bought-in components and services that are part of the current costs of production. Layering, as noted in the main text, refers to the high-level process that the ONS undertakes to ensure consistency of the production, income and expenditure measures of GDP in Blue Book rounds that are not subject to a full SUTs rebalancing procedure. In contrast to the impact on gross operating surplus, saving and gross fixed capital formation, the financial balance has been comparatively, if not wholly, unaffected by capitalisation and layered balancing.

For the corporate sector, capitalisation has resulted in equal increases in value added, gross operating surplus and fixed capital formation. The impact can be seen most clearly in the revisions introduced in the 2007 Blue Book round, as shown in Table 3. Investment in computer software, already capitalised as a result of changes introduced under ESA95, was revised up from 1970. Details of the revisions and the balanced way they were captured in the accounts are given in Chamberlin et al. (2007) and the 2007 Blue Book (p30). The 1987 values of gross operating surplus and gross fixed capital formation were each revised up by the equivalent of 0.2 per cent of GDP, with the financial balance unaffected. The official revisions to gross operating surplus and gross fixed capital formation, the latter properly calculated only from 1987, remained equal in each year of the subsequent interval to 2004.

ESA10 introduced in the 2014 Blue Book continued the process of widening the definition of intangible fixed assets – renamed, "intellectual property products" - to include previously missing expenditure on Research and Development (R&D), notably the R&D undertaken by businesses, not for sale, but for their own use. The detailed estimates and the balanced method by which they were incorporated in the national accounts are described in Kerr (2014) and Abramsky (2014).

The 2014 Blue Book revision to 1987 estimates of PNFC R&D is surprisingly difficult to ascertain, but it is clear that the revision for this reason falls short of the full 3½ per cent of GDP upward revision to PNFC gross fixed capital formation. The difficulty of estimating the impact on R&D stems from gaps over several years in the ONS detailed record, the result of the agency's struggles with a new computer system and a revised Standard Industrial Classification: some details are given in Everett (2011). It is also unfortunate that corrected 2013 Blue Book figures at the necessary level of detail published by the ONS in July 2014 were subsequently overwritten with 2015 Blue Book values. Some guide is

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nevertheless to be had from a comparison of the estimates for PNFC gross fixed capital formation in 1987 provided in the (ESA95) 2010 Blue Book and (ESA10) 2015 Blue Book under the intangible and intellectual property products headings. The comparison suggests that the capitalisation of R&D raised PNFC gross fixed capital formation in 1987 by the equivalent of 2½ per cent of GDP.

It may be inferred that the remaining part – perhaps worth 1 per cent of GDP – of the upward revision to PNFC gross fixed capital formation in 1987 came from changes outwith the capitalisation of R&D spending, and from the new way in which the ONS backcast its estimates. The newly published 2014 Blue Book data for gross fixed capital formation, incorporating both ESA10-related and other revisions, began in 1997. Initially, data before 1997 were absent. To backcast gross fixed capital formation, the ONS chose to splice old data to the new data at the 1997 link year and revised the method of apportioning to each of the institutional sectors the backcast whole economy fixed investment total categorised by asset. Davies et al. (2015) briefly describe the backcasting method. Background details are given in Mosquera et al. (2014). Later modifications noted in Harris (2015) had no impact on 1987 values for the main institutional sectors or for the economy as a whole.

The result of 2014 Blue Book changes, not limited to the capitalisation of R&D, was a large upward revision to the value of gross fixed capital formation. For the whole economy, the revision was equivalent to 5 per cent of GDP in 1987, by far the largest single contributor to the 5¼ per cent upward revision to the level of GDP itself. The revisions to gross fixed capital formation, and thus to the expenditure measure of GDP, were balanced with revisions to the production and income measures of GDP. An extensive search does not uncover any publicly available documentation that describes the detail of the ONS balancing process affecting values in 1987. However, it is a matter of logic to say that, save for changes to other components of the income measure of GDP, the upward revision to GDP measured from the income side required to balance the upward revision to GDP measured from the expenditure side would come from an upward revision to gross operating surplus. This is what happened. The 5¼ per cent upward revision to the value of GDP in 1987 came with an upward revision to economy-wide gross operating surplus equivalent to 4¾ per cent of GDP. Other revisions as a percentage of GDP were much smaller: an upward revision to mixed income of ¾ per cent, and a downward revision to compensation of employees of ¼ per cent. The national accounts residual error was unchanged, not only in 1987 but all the way back to 1948.

The conclusion is that the concurrent revisions to 1987 values of PNFC gross fixed capital formation and to gross operating surplus recorded in Table 3 are causally related. In the 2007 Blue Book round, the revisions are equal, the result of the capitalisation of revised software expenditure data. The far more complex

revisions involving both capitalisation of intangibles and the rebalancing of revised historic investment data in the 2014 Blue Book round were associated with closely, but not exactly, matching revisions to the 1987 values of PNFC gross operating surplus and gross fixed capital formation. Consequently, there was comparatively little impact on the 1987 value of the PNFC financial balance.

c) Defined Benefit Pensions

With the conversion to ESA10 in 2014 came a change to the valuation of pensions that had the effect of reducing PNFC gross operating surplus. The impact in 1987 is not publicly documented but might have been of the order of ¼ per cent of GDP. Subsequent revisions in the 2018 Blue Book may have reduced that impact by half. The impact of the revised pension valuation method on PNFC gross operating surplus, the sole focus of this annex, was minor by comparison with the effect on the measurement of property income, an impact which radically affected the accounts of households, the sole beneficiaries of pension schemes, and the financial corporations sector, which includes the sub-group comprising insurance corporations and pension funds (ICPF). An assessment of the possible historical impact on PNFC gross operating surplus before 1987 requires an understanding of the complex pension valuation and measurement changes, which are simplified in the summary below.

ESA10 introduced into the PNFC generation of income accounts the effect of notional pension contributions not actually paid but, in principle, payable by companies in order to correct shortfalls in occupational pension provision for which the companies were deemed to be legally responsible. As with other non-wage contributions made for the benefit of a company's employees, the notional payments, formally referred to as "employers' imputed pension contributions", are treated within the PNFC accounts as part of labour compensation, and as such come at the expense of company profits. The pensions that count for this new treatment are "funded" - underpinned by a saving pot - and for which the "sponsoring" company (confusingly referred to as the "Pension Manager" under ESA10) is ultimately held responsible in the event of a funding deficit. A funding deficit – a balance sheet concept - occurs when a plan's liabilities, actuarially calculated, exceed the plan's assets.

The type of plans singled out for this new treatment provide defined benefit (DB) pensions, so called because the rules of the scheme define in advance the level of pension payable to the scheme members when they retire. In the past, a typical DB scheme would provide a pension fixed as a proportion of a member's final salary and depend on the rate at which pension rights accrue each year and the member's length of "service": the number of years of work that confer pension rights. Under pressure of tighter legislation and to escape the financial burden, actual or feared, of making good pension fund deficits, companies have scaled back DB provision and increasingly offered in its place the alternative pension

arrangement, known as defined contribution (DC). The pension received by an individual with a DC workplace pension arrangement is not defined in advance of retirement; instead the DC pension depends solely on the accumulated contributions made to the saving fund, the resulting investment income, and the rate at which the final saving pot is converted into the form of an annuity or drawn down. An annuity-in-payment is now classified under ESA10 as defined-benefit, being a liability of the insurer who sells the annuity product. But this complication does not affect the position of the employer, who may contribute to the DC pension fund while it is being accumulated on behalf of an employee. The employer is not held responsible for the DC pension eventually paid, and is therefore absolved under ESA10 from making any imputed pension contribution.

There are two types of official calculation of employers' imputed pension contributions. One type appears in a Supplementary Table on pensions ("Table 29"), introduced under ESA10 to complement the incomplete national accounts depiction of pensions, in which is found the second type of official calculation. The Supplementary Table calculations attempt fully to meet ESA10 stipulations; the national accounts calculations are an approximation.
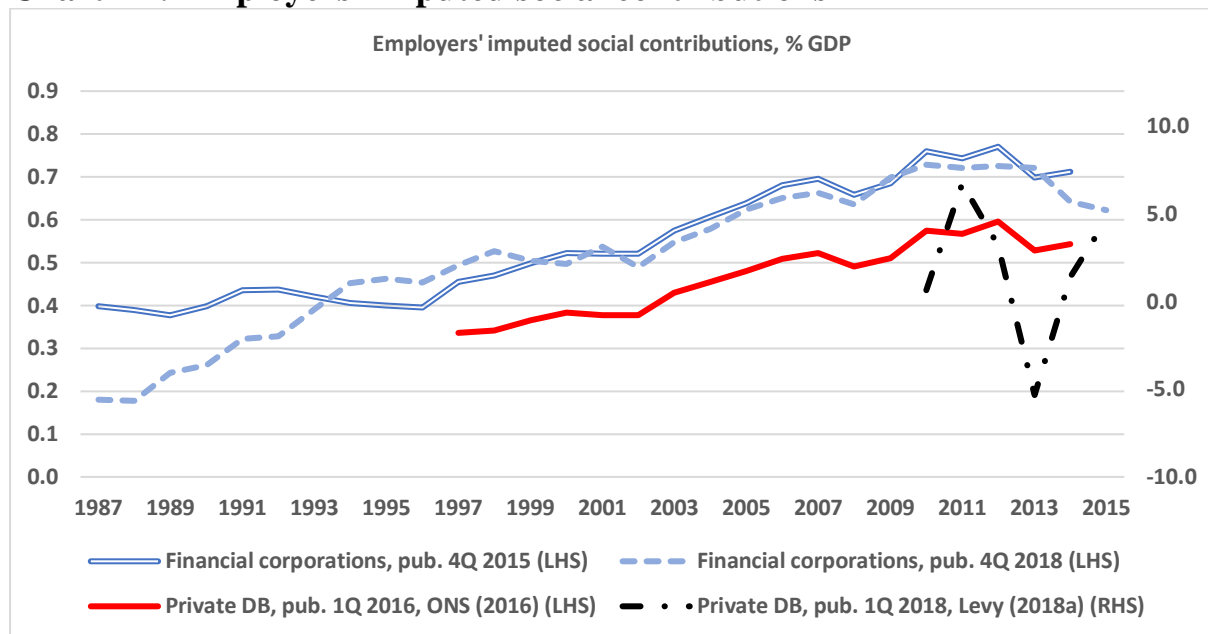
In the Supplementary Table, employers' imputed pension contributions are treated as a balancing item that ensures the equality in any one year of, on the one hand, the change in accumulating DB pension entitlements from the beginning of the year to the end of the year, and, on the other hand, the sum of other flows into and out of the schemes during the year. The sum of all flows, including the imputed contributions, should equate with the change in pension entitlements. The entitlements are calculated actuarially. They represent the present value of the sum of future pension payments based on the rights of scheme members accrued to the date of the valuation but with an allowance, under what is called the projected benefit obligations approach, for the projected earnings of employed members until their retirement. In ONS calculations, the present value of future pension payments arising from private sector plans is derived from regulatory data compiled using a "risk-free" rate of discount.

The present value of DB entitlements can change over a year for many reasons: for example, as a result of the accrual by employees of an extra year of service (the "current service increase"); because of changes in actuarial assumptions – financial, demographic – that have been overturned by events ("experience effects"); because of changes in the rules of the DB scheme. Irrespective of the source of the change in DB pension entitlements, employers' imputed pension contributions are deemed to fill any gap between that change and the net sum of other flows during the year: the total of employers' and employees' actual contributions and schemes' notional property income, net of any pensions paid and the costs ("service charges") of running the schemes. It is perhaps not surprising that the ONS current Head of Pensions has described the notion of

employers' imputed pension contributions as "perhaps one of the most difficult to interpret in the supplementary table" (Levy, 2011), nor that the resulting imputed series is highly volatile. Such estimates as exist, as of this writing from 2010 to 2015, are described in Levy (2018a).

Chart B1 depicts these data expressed as a per cent share of GDP for DB schemes that are sponsored by corporations and are not, as in the case of the Local Government Pension Scheme and others with Crown guarantees, the responsibility of government. This "private sector" DB series of imputed contributions, charted against the right-hand scale, is highly volatile, ranging from 6¾ per cent of GDP in 2011 to *minus* 5¼ per cent of GDP in 2013.

Chart B1: Employers' imputed social contributions

Sources: UK *Economic Accounts:* Financial corporations, secondary distribution of income account, employers' imputed social contributions (ESA10 transaction code: D.612) comprising employers' imputed pension contributions (D.6121) and employers' imputed non-pension contributions (D.6122), ONS (2016), Levy (2018a). Notes: "pub." – published. LHS, RHS – left-hand scale, right-hand scale. "Private DB" – employers' imputed pension contributions to DB and "hybrid" (a mixture of DB and DC) pension plans that are not the responsibility of local or central government. The ONS (2016) figures are national accounts data; the Levy (2018a) figures are from Supplementary Table 29 on "Accrued-to-date pension entitlements in social insurance (pensions in National Accounts)".

In contrast to the Supplementary Table series, the national accounts estimates are markedly different in size and volatility. They are also depicted in Chart B1 but against the smaller-scale left hand axis. Compared with the latest available

Supplementary Table estimates published in 2018, the national accounts data, available from 1997 to 2014, are of an older vintage, published only once in early-2016 in response to a "user" request (ONS, 2016). The difference in data vintages is not however the cause of the marked difference in the two sets of estimates. Over the 2010 to 2014 interval, the annual average of imputed DB pension contributions recorded in the Supplementary Table is twice that shown in the national accounts. The volatility of the Supplementary Table estimates is an order of magnitude greater compared with the comparatively smooth national accounts series.

The national accounts estimates take advantage of the second best method permitted by Eurostat, the statistical agency of the European Union, should statistical agencies not have the requisite actuarial data to perform a full calculation. Under a second-best method, employers' imputed pension contributions can be calculated as a "reasonable percentage of wages and salaries paid current employees" (Eurostat, 2014, p.110, paragraph 4.97). Lacking data before 2010, the starting date of the actuarial information taken from the UK Pension Protection Fund's *Purple Book,* the ONS uses the permitted second-best method for "private sector" DB schemes. The precise assumptions are not publicly documented but it may be inferred from contemporaneous records that the national accounts imputed contributions published in 2016 were the equivalent of 2 per cent of the employers' wage and salary bill over the 2010 to 2014 interval, up from 1¼ per cent in 1997.

With this information, it is possible to backcast to 1987 PNFC employers' imputed pension contributions in a way that is consistent with the national accounts record of pension funds' (strictly financial corporations') receipts of imputed contributions that is regularly published in the *UK Economic Accounts*. This series is also depicted in Chart B1. The regularly published total includes employers' imputed non-pension contributions and the imputed pension contributions of those who sponsor DB pensions in the public and private sectors, including PNFC. A certain amount of approximation is required to split out the various components. This procedure yields the rough estimate of the ESA10 negative impact of employers' imputed pension contributions on PNFC gross operating surplus in 1987 of ¼ per cent of GDP cited at the beginning of this section.

Until the 2018 Blue Book, all the national accounts estimates for the imputed contributions to DB schemes were derived in a second best manner as a percentage of wages and salaries, whether or not the DB schemes concerned were sponsored by private corporations or were the responsibility of government. Beginning with the 2018 Blue Book, the national accounts estimates for the government-classified DB schemes were put on a first best basis, consistent with the calculation in the Supplementary Table (Levy, 2018a). It is not clear from the

published official documentation whether the first best method was applied before 1997, the starting date of the regular ONS analysis of revisions (Arias, 2018b). Earlier data may have been "modelled" by the ONS. Chart B1 shows that the national accounts record of financial corporations' receipts of employers' imputed social contributions was indeed revised in the 2018 Blue Book, with the revisions running back to 1987. Unaccountably, the revisions were materially more negative during the 1987 to 1990 interval than subsequently. It is possible that an undocumented change or a modelling assumption may have affected the 1987 value of private sector employers' imputed pension contributions.

It is concluded that the ESA10 changes affecting the valuation of DB pension schemes had a backwards decreasing impact on PNFC gross operating surplus as recorded in the national accounts. In principle, employers' imputed pension contributions could be negative or positive, small or large. In practice, the national accounting method used to calculate the imputed contributions in cases where the employer is a private corporation smooths out the potentially volatile estimates, which are, on average, small. The impact on PNFC gross operating surplus in 1987 was negligible.

d) Miscellaneous revisions

In addition to the revisions arising from the new FISIM calculations introduced in 2008, from the capitalisation and layered balancing of revised fixed capital formation data in the 2007 and 2014 Blue Book rounds, and, again in 2014, from the introduction of an actuarial valuation of DB pension entitlements, there remains a number of generally small revisions in Table 3 arising for miscellaneous reasons. In many cases, it is difficult to trace the root cause. Rarely extending back before 1997, the available ONS analyses of annual revisions can only provide clues to the reasons for the revisions to 1987 values of PNFC sector series. Revisions to 1997 values can be an unreliable guide. The list that follows comprises revisions to insurance services in the 2012 Blue Book, to PNFC current transfers in the 2017 Blue Book, to PNFC other investment income, a component of property income, in the 2014 Blue Book, and the remaining unaccounted-for revisions to PNFC gross operating surplus.

(i)   Insurance services:2012 Blue Book

To comply with a European requirement, known as a "reservation", the ONS revised its measurement of insurance services in the 2012 Blue Book round. Details of the new method and its impact from 1997 are given in Williams et al. (2012a; 2012b). Other sectors' intermediate consumption of direct insurance services – as distinct from reinsurance services - was generally revised down. The impact on earlier national accounts data is unclear. A contemporaneous document (ONS, 2012) states that the new insurance figures were "calculated back to 1995"; Walton (2020) states, however, that the revisions to clear the reservation were
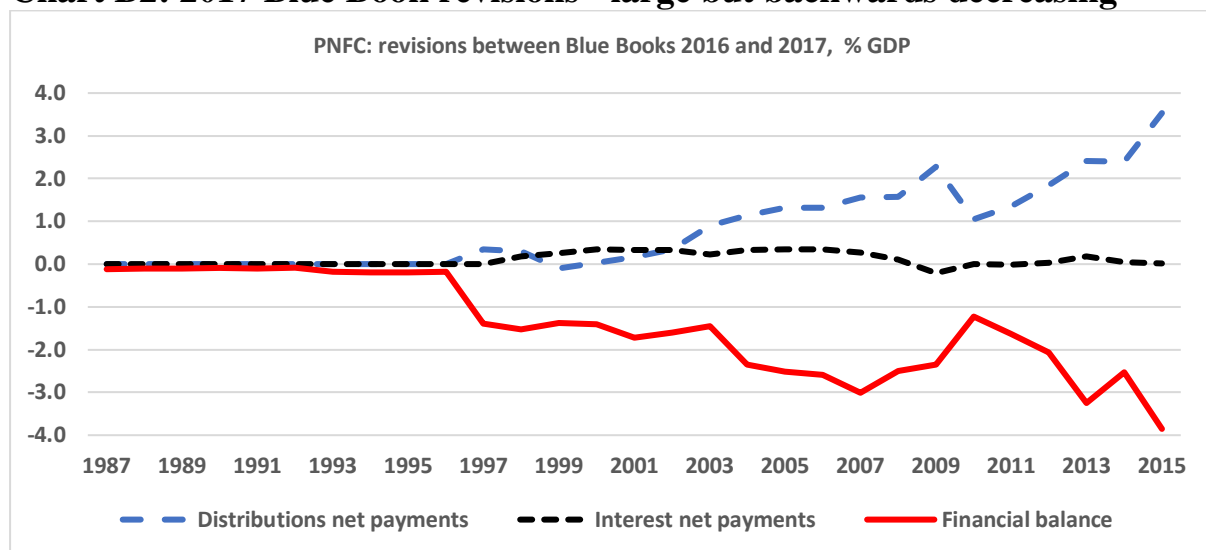
"taken back to 1987". The 2012 Blue Book refers to revisions to GDP from 1987 to 2010 as a result of, amongst other things, the changed method of measuring insurance services and the "balancing of those years through the supply and use framework".

It may be reasonable to infer that changes related to the new measurement of insurance services explain the 2012 Blue Book revisions to the value of PNFC gross operating surplus. Whatever the cause, the incremental revisions are small and backwards decreasing. After a peak equivalent of 0.5 per cent of GDP in 1995, the revision to PNFC gross operating surplus falls by 1987 to the 0.1 per cent of GDP figure shown in Table 3. Calculation of the incremental 2012 Blue Book revisions before 1987 is not possible, a casualty of the 2011 ONS purge of historic data.

(ii)   Current transfers: 2017 Blue Book

Vassilev et al. (2017) detail the re-assessment of the accounts of non-profit institutions serving households (NPISH) which led to an upward revision in the 2017 Blue Book of PNFC current transfer payments, and a corresponding reduction in PNFC net current transfer income - receipts less payments – equivalent to about ¼ per cent of GDP in most years back to 1987.

Chart B2: 2017 Blue Book revisions - large but backwards decreasing

Sources and notes: see main text Table 3. "Distributions net payments" refer to the distributed income of PNFC, payments less receipts.

It is of interest to note the large but strongly backwards decreasing impact of the far more radical revisions in the 2017 Blue Book to dividend and interest payments, as shown in Chart B2. The revision to dividends was a recognition by the ONS of a previous understatement of dividends that were paid by the growing number of self-employed business owners who were choosing to incorporate. The owners received income treated in the national accounts as dividends rather than wages. The revision to interest paid by corporations on their UK-issued bonds, as

described by Crane (2017), was a recognition of the implausibly low rates of interest implied by previous estimates of interest payments. The implied interest rate on corporate bonds was generally lower, rather than higher, than the rate on less risky UK government bonds. Neither of these radical revisions had any impact on PNFC series values in 1987, and so may be eliminated from consideration when assessing the resurrection of the PNFC accounts before 1987.

(iii) Other investment income (2014 Blue Book)

An extensive search of official documentation sheds no light on the cause of the upward revision in the 2014 Blue Book round to PNFC other investment income; specifically, to the imputed investment income PNFC receive from insurance companies. The accounting concepts are convoluted. The interest, dividend and other property income under this heading accrue to the insurers themselves, the result of their financial and other investments of the accumulated sums ("technical reserves") they set aside to meet insurance claims. The national accounts show insurers' investment income flowing to the insurance policy holders – mainly households – and, then, back to the "insurance enterprises and pension funds in the form of premium and contribution supplements" (Doggett, 1998, p447 explains the accounting under ESA95). In this accounting roundabout, the small part of the total imputed flow of insurers' property income that PNFC receive as insurance policy holders is returned by PNFC to the insurers in the form of consumption of insurance services.

The reason for the revision during the 2014 Blue Book round is unclear. The conversion to ESA10 is not obviously implicated. The conversion added a more detailed coverage of "other investment income", which henceforth distinguished between three types of property income, all imputed, arising from (a) the ownership of insurance, (b) entitlements to pensions and (c) the ownership of investments in collective funds, such as unit trusts. In principle, ESA10 also amended the treatment of non-life insurance, making the measure of the insurance "service charge" – insurance output - less volatile in the face of exceptional claims. A technical manual published by Eurostat describes the measurement changes, noting the impact on the "intermediate consumption of policy holders which use the policies in the act of further production" but not on insurers' investment income (Eurostat, 2014). It is unclear whether the alteration described by Eurostat was implemented by the ONS.

Further exploration of the matter would be disproportionate in the view of the minute scale of the 2014 Blue Book revision. In each year back to 1987, the revision to PNFC other investment income is less than 0.1 per cent of GDP, and frequently zero.

(iv)   Other revisions to PNFC gross operating surplus

There remain for consideration other unaccounted-for revisions to the 1987 value of PNFC operating surplus. Upward revisions that are not explained by capitalisation or by the balancing of revised estimates of gross fixed capital formation occurred in both the 2014 and 2017 Blue Book rounds. In the former case, it is documented in Davies et al. (2014) that amendments to NPISH sector data led, on average, to upward revisions to PNFC operating surplus from 1997. However, the impact, if any, in 1987 is unclear. It was noted in an earlier ONS brief on the NPISH revisions published in May 2014 that the possibility of revising data before 1997 was still "being investigated" (Howe, 2014). The 2017 Blue Book round introduced further revisions to the NPISH sector, with the result that PNFC gross operating surplus in 1997 and in the following years was revised down. Kent (2017) and the updated dataset provided by Arias (2018a) quantify from 1997 the impact of the NPISH methodological changes detailed in Vassilev et al. (2017). None of the 2017 documents explains why in the period before 1997, back to 1948, PNFC gross operating surplus was instead revised up.

Annex C: Historic data on reinvested FDI earnings

Comprehensive economy-wide and sectoral official data for reinvested earnings derived from foreign direct investment (FDI) begin in 1987. To backcast these series, use may be made of pre-ESA95 whole economy data last published in the 1997 Blue Book and early-1998 *UK Economic Account*s and of a comparable (ESA95) PNFC series last published in the *UK Economic Accounts* in the second quarter of 2007. The impact of subsequent official revisions to both these datasets appears to be sharply backwards decreasing, tending to zero before 1987.

Supporting evidence for this observation comes from the official "Pink Book" series for whole economy net reinvested FDI earnings (outward FDI reinvested earnings minus inward FDI reinvested earnings) found with sign reversed in the financial account of the UK international balance of payments (ONS code HBWT). The Pink Book series is exceptional in beginning in 1985, and so in providing information on the overlap with earlier vintage data before the 1987 cut-off date. The 2019 Pink Book, the latest available as of this writing, records net reinvested FDI earnings of £1,089 million and £3,293 million in 1985 and 1986 respectively. The pre-ESA95 figure is almost identical in 1985 (£1,086 million) and identical in 1986.

The closeness of the figures across these two accounting standards in 1985 and 1986 comes despite the many subsequent changes of definition and data sampling. These changes include: (a) the lowering of the minimum threshold equity stake, from 20 per cent to 10 per cent of the voting share capital of the overseas enterprise, that is required for the overseas investment to be categorised as direct investment rather than as portfolio investment; (b) the deduction from earnings of inventory valuation gains ("stock appreciation""), although the 2001 Pink Book (p174) is untypically explicit in noting that "In practice, stock appreciation and some of these [unrealised capital] gains and losses are included in earnings …"; (c) a revised sampling frame in 2002; and (d) changes in the treatment of withholding taxes. ONS (2017) gives further details. Additional changes were introduced with the inception of ESA10 in 2014, notably the exclusion of holding gains and losses from banks' ("monetary financial institutions") FDI earnings. The impact was a large downward revision to banks' net FDI income during the financial crisis in 2008 and 2009. From a backcasting perspective, it is helpful that the revisions prior to the crisis were comparatively small, if not trivial (Smith and Bowers, 2014; Dobbins et al., 2016). The indicative revisions in the 1997 to 1999 interval amounted to just £1 million each year (Smith et al., 2014). Other changes followed a National Statistics Quality Review of the FDI data (James, 2016; Hamroush, 2017).

Chart C1 shows the impact of these changes of concept and measurement practice on the record of the whole economy FDI reinvested earnings balance, comparing the latest Pink Book data with the last available pre-ESA95 data. Each series is
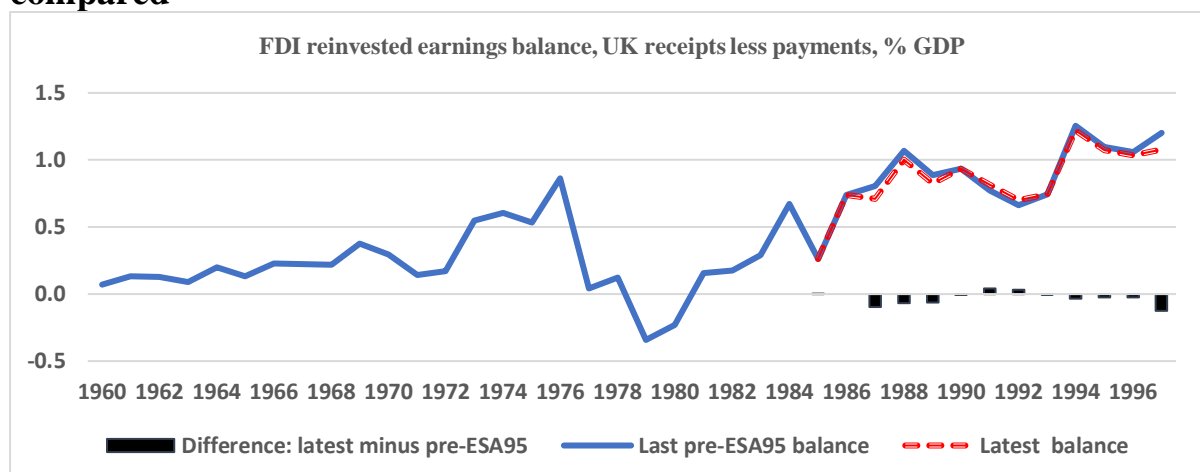
expressed as a per cent share of 2019 Blue Book consistent GDP. In addition to the closeness of the estimates in 1985 and the identical data in 1986, the chart shows that subsequent revisions had little impact during the overlapping period up to 1997. The mean and absolute mean annual revisions between 1987 and 1997 are both zero expressed to one decimal place. The FDI reinvested earnings balance averaged 0.9 per cent of GDP over the same period.

On this rationale, the last pre-ESA95 data are used to backfill the historic series for total FDI reinvested earnings receipts (outward FDI) and payments (inward FDI). The pre-ESA95 data are available from 1960. The inward FDI series is adjusted for the minor 1985 discrepancy noted above.

It is additionally possible to backcast these totals split between the PNFC and financial corporate sectors, granted the strong assumption that public corporations reinvested FDI earnings before 1987 were zero. The 1997 Blue Book provides a series (ONS code AIBP) for "net unremitted profits", the former term for net reinvested earnings, for the industrial and commercial company sector. Save for a discrepancy in 1964 of £30 million, this pre-ESA95 series squares before 1987 with purportedly ESA95 consistent data for PNFC FDI reinvested earnings credits and debits published in the *UK Economic Accounts* in the second quarter of 2007, just before the ONS data purge (ONS codes: HDVR and HDVB). This publication, and similar vintages, are vulnerable to database corruption. It is therefore reassuring that the ESA95 data are also consistent with the FDI unremitted profits credits and debits presented by Pettigrew (1978) as contributors to the "net borrowing requirement" of industrial and commercial companies.

The mid-2007 *UK Economic Accounts* PNFC data for outward FDI reinvested earnings, adjusted in 1964 to align with the 1997 Blue Book series, and for inward FDI reinvested earnings are used to backfill the historic data to 1963. Data for financial corporations are inferred by residual back to 1963, and assumed zero before 1963, with PNFC data thus equated with the whole economy total in the 1960 to 1962 interval.

Chart C1: Whole economy FDI reinvested earnings balance, data vintages compared

FDI reinvested earnings balance, UK receipts less payments, % GDP

Legend: Difference: latest minus pre-ESA95 | Last pre-ESA95 balance | Latest balance

Sources: 1997 Blue Book; *UK Economic Acc*ounts published 2Q 1998 ("Last pre-ESA95 data"); 2019 Pink Book and Blue Book. Notes: Pre-ESA95 FDI balance is calculated as the FDI unremitted profits of overseas subsidiaries and associates of UK parent companies and public corporations (ONS code HHDR, with reverse sign, or CGQY) – these data exclude oil companies before 1984 – less the sum of the unremitted profits of UK subsidiaries and associates of overseas parent companies, non-oil (ONS code CGLU or HBZT) and private oil companies (ONS code HERX). These data exclude the not-separately-reported unremitted FDI profits of (wholly-owned) branches. Pettigrew (1978) notes that "rough estimates" of the unremitted profits of the branches of non-oil companies were "quite small" in the 1973 to 1977 interval. The latest estimate of the FDI reinvested earnings balance is equal to the latest Pink Book series database code HBWT with sign reversed. The FDI reinvested earnings balances are expressed as a per cent share of the 2019 Blue Book consistent GDP data.

Annex D: Revising the household and corporate sector capital accounts

The availability of PNFC capital account series in the 2001 Blue Book and the backcasting of PNFC gross fixed capital formation make it both possible and necessary to recalculate the household and corporate capital accounts presented in Martin (2019). Consideration is given in turn to five items: gross fixed capital formation, changes in inventories, capital taxes, net other capital transfers and other capital account items.

a) Gross fixed capital formation

A significant weakness noted in Martin (2019) was its deployment of a mechanical method to backcast household and corporate sector gross fixed capital formation. Specially reconstructed pre-ESA95 data were spliced to 1987 values to form historic proxy series which were pro-rated to align their sum with the private sector total for gross fixed capital formation. The latter acted as a fixed control total, being derived by identity from whole-economy and public sector finances series. With historic PNFC gross fixed capital formation data derived in a manner consistent with observed revisions to PNFC gross operating surplus, the relevant control total can be recalculated as the gross fixed capital formation of the remaining sectors: households and financial corporations. Save for the amended control total, the mechanical method can be reapplied largely unchanged to derive estimates that make best use of the available data while observing the relevant accounting constraint.

The method, fully explained in Martin (2019), can be presented formally as the solution to a quadratic minimisation problem that yields the most reliable estimates of the unknown series:

$$\widehat{I}_{h,t} = \vec{I}_{h,t} + u_{h,t}\left(I_{hm,t} - \vec{I}_{hm,t} \right)$$
$$\widehat{I}_{m,t} = \vec{I}_{m,t} + u_{m,t}\left(I_{hm,t} - \vec{I}_{hm,t} \right)$$

(D1)

Equation (D1) shows these most reliable estimates of gross fixed capital formation at time "t", denoted "$\widehat{I}_{h,t}$" and "$\widehat{I}_{m,t}$", for, respectively, the household sector and financial – inter*m*ediation - corporations, subscripted "h" and "m", as the sum of (a) each sector's proxy series, denoted "$\vec{I}_{h,t}$" and "$\vec{I}_{m,t}$", and (b) a proportion of the discrepancy between the control total, denoted "$I_{hm,t}$", and the sum of the proxy series, denoted "$\vec{I}_{hm,t}$". The latter is defined by identity (D2):

$$\vec{I}_{hm,t} \equiv \vec{I}_{h,t} + \vec{I}_{m,t}$$

(D2)

The proportions denoted "$u_{h,t}$" and "$u_{m,t}$", measure the relative unreliability of each sector's proxy series. Equation (D1) shows that the more relatively

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unreliable the proxy, the more of the control total discrepancy is added in the calculation of the most reliable estimate.

Lacking information on the relative unreliability of the proxy series, the crude assumption is made that the unreliability weights are equal to the share of each sector's proxy series in the proxy sum:

$$u_{h,t} = \frac{\vec{I}_{h,t}}{\vec{I}_{hm,t}} \text{ and } u_{m,t} = \frac{\vec{I}_{m,t}}{\vec{I}_{hm,t}} \tag{D3}$$
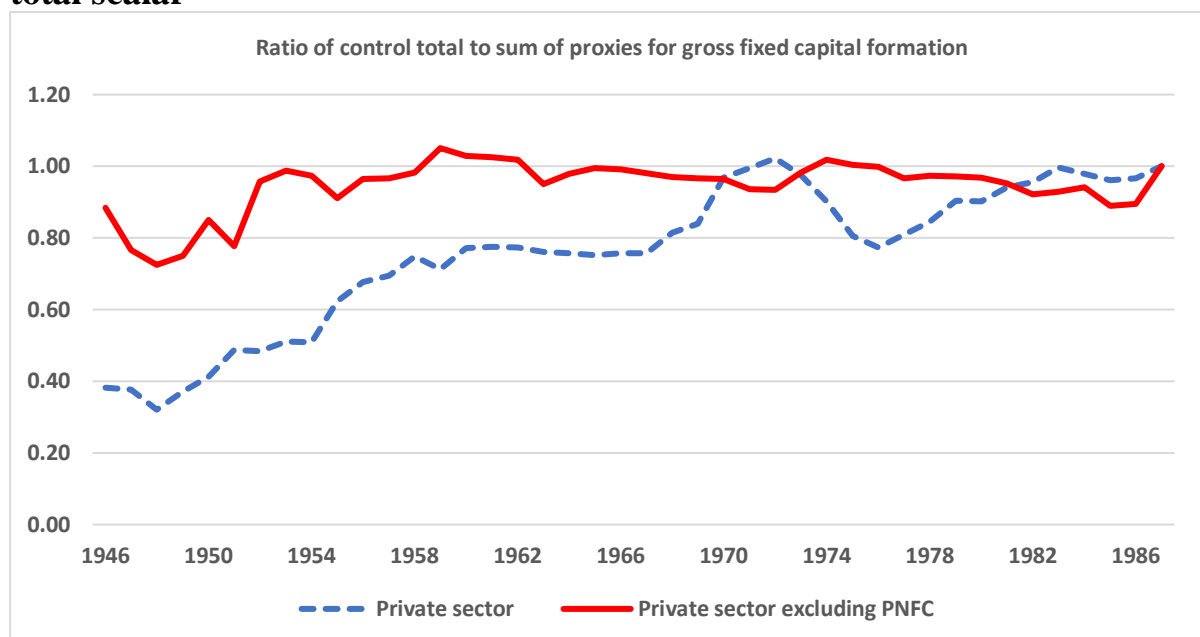
The combination of (D1) and (D3) yields the simple pro-rating formulae:

$$\hat{I}_{h,t} = \vec{I}_{h,t} \frac{I_{hm,t}}{\vec{I}_{hm,t}}$$

$$\hat{I}_{m,t} = \vec{I}_{m,t} \frac{I_{hm,t}}{\vec{I}_{hm,t}} \tag{D4}$$

Although crudely mechanical, the method is not without some merit. It avoids the error of assuming that any one of the proxy series is wholly reliable, leaving the other series to be derived residually. In addition, the unreliability weight given to each proxy series is directly related to its relative size, a procedure not inconsistent with an assumption of heteroscedastic measurement error.

In re-applying this method, a distinction is made, as before, between household sector dwelling and non-dwelling gross fixed capital formation. For the financial corporations sector, the pre-ESA95 data used to form the relevant proxy series are taken from the 1997 Blue Book and early-1998 *UK Economic Accounts* back to 1963, and before 1963 are backcast as a constant share of private corporate sector gross fixed capital formation. For the years 1946 and 1947, two changes are made. The PNFC data derived using the balanced method described in the main text are backcast two years to 1946 by splicing the pre-ESA95 data, also backcast, for industrial and commercial companies. Consistently, the economy-wide gross fixed capital formation data in 1946 and 1947 are derived as the sum of general government and public corporations gross fixed capital formation data, taken from PSAT accounts, and data for the private sector backcast by splicing the equivalent pre-ESA95 series.

Chart D1: Impact of gross fixed capital formation recalculation on control total scalar

Ratio of control total to sum of proxies for gross fixed capital formation

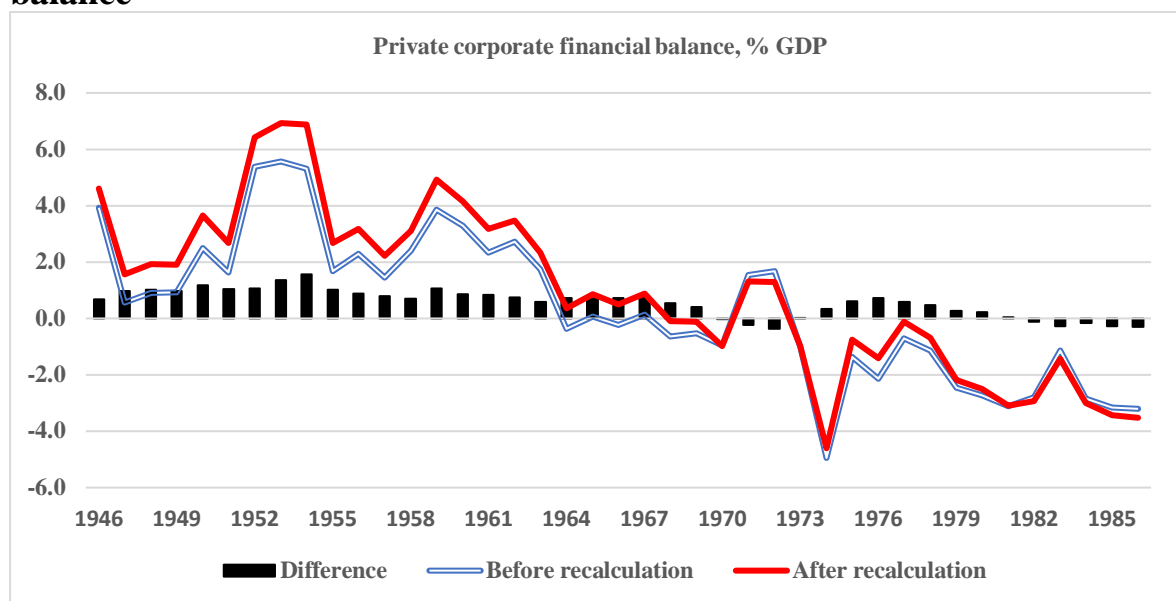Private sector · · · · · Private sector excluding PNFC ——

Sources: 1997 Blue Book, *UK Economic Accounts* published 1Q 2019, 3Q 2019, PSAT published 1Q 2019, 3Q 2019. Notes: Series show gross fixed capital formation control total for the aggregate sector divided by the sum of proxy series for the sectors that comprise the aggregate sector.

Chart D1 shows the impact of the amended method on the scalar, $\frac{I_{j,t}}{\overline{I}_{j,t}}$, where the "*j*" subscript denotes the relevant aggregation of sectors. The impact is material. Under the previous method, the scalar that applied to the private sector as a whole fell dramatically in the period before 1960, and oscillated in the 1970s. This pattern picks up the peculiarities in the official gross fixed capital formation data. Under the new method that deducts balanced estimates of PNFC gross fixed capital formation from the control total, the scalar remains much closer to unity for the period back to 1952, and does not decline as markedly in the early post-war years.

The differences in the scalars and the use of balanced PNFC data lead to significant revisions, at least before 1960, to the backcast estimates of sectors' gross fixed capital formation. Compared to the previous method, backcast household gross fixed capital formation is generally revised up, and backcast corporate sector gross fixed capital formation is generally revised down. Chart D2 shows the impact on the private corporate sector financial balance, which is revised up, on average, by 1 per cent of GDP before 1960 and by ¼ per cent of GDP subsequently. The impact is larger in the 1960s, and then diminishes. With the private sector totals unchanged, there are corresponding revisions in the opposite direction to the household sector's gross fixed capital formation and financial balance.

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Chart D2: Impact of gross fixed capital formation recalculation on financial balance

Private corporate financial balance, % GDP

Legend: Difference | Before recalculation | After recalculation

Sources: 1997 Blue Book; *UK Economic Acc*ounts published 2Q 1998, 1Q 2019 and 3Q 2019; PSAT published 1Q 2019 and 3Q 2019. Notes: see text for explanation of method.
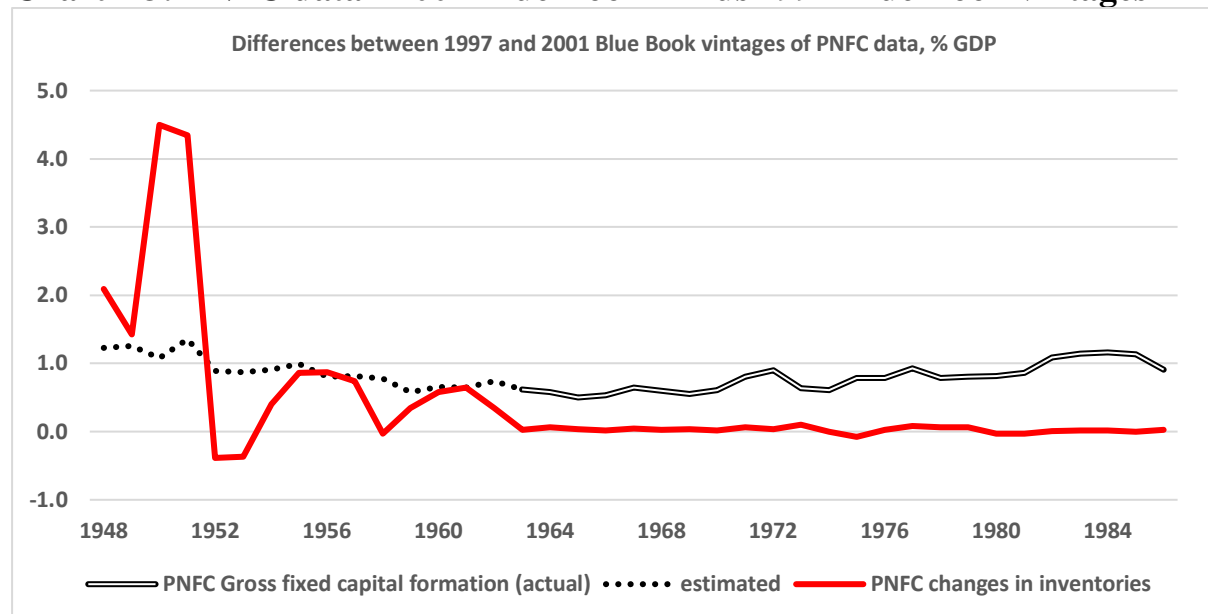
b) Changes in inventories

The 2001 Blue Book provides data for PNFC changes in inventories ("stockbuilding") back to 1948, but there are grounds to believe the data are wrong for the earliest years.

Chart D3 shows the revisions to the PNFC stockbuilding data, comparing the 2001 Blue Book PNFC data with the 1997 Blue Book data for industrial and commercial companies. The differences between the two vintages are shown as a per cent share of the latest estimate of GDP. The two stockbuilding series can be expected to differ to some degree as a result of the ESA95 reclassification of partnerships, moved from the former personal sector. However, the differences between the two data vintages are extreme in earlier years. In 1950 and 1951, the upward revisions to PNFC stockbuilding exceed 4 per cent of GDP. Since there were no revisions to economy-wide stockbuilding data, which remain unchanged in the latest available estimates, and little revision to public sector stockbuilding data, the large upward revision to PNFC stockbuilding in the 2001 Blue Book implies a wholly implausible downward revision to household sector stockbuilding, equivalent over the two years 1950 and 1951 to over half the outstanding level of personal sector inventories. Table D1 gives details.

The conclusion is that the early period 2001 Blue Book PNFC data for stockbuilding are incorrect. Since comprehensive PNFC sector data are available from 1960, the decision is taken to use 1997 Blue Book data to represent PNFC stockbuilding before 1960. Minor and sporadic amounts of stockbuilding by financial corporations are equated with 1997 Blue Book data in the historic period back to 1963, and before then assumed to be zero. Household sector stockbuilding in the historic period is derived by residual, replacing the crude method described in Martin (2019).

Chart D3: PNFC data - 2001 Blue Book minus 1997 Blue Book vintages

Differences between 1997 and 2001 Blue Book vintages of PNFC data, % GDP

Sources: 1997 and 2001 Blue Books; Sefton and Weale (1995); *UK Economic Acc*ounts published 2Q 1998 and 4Q 2019; PSAT published 4Q 2019. For changes in inventories, see notes to Table D1. 1997 Blue Book data for ICC gross fixed capital formation are backcast before 1963 as a constant (1963) share of private corporate sector gross fixed capital formation.

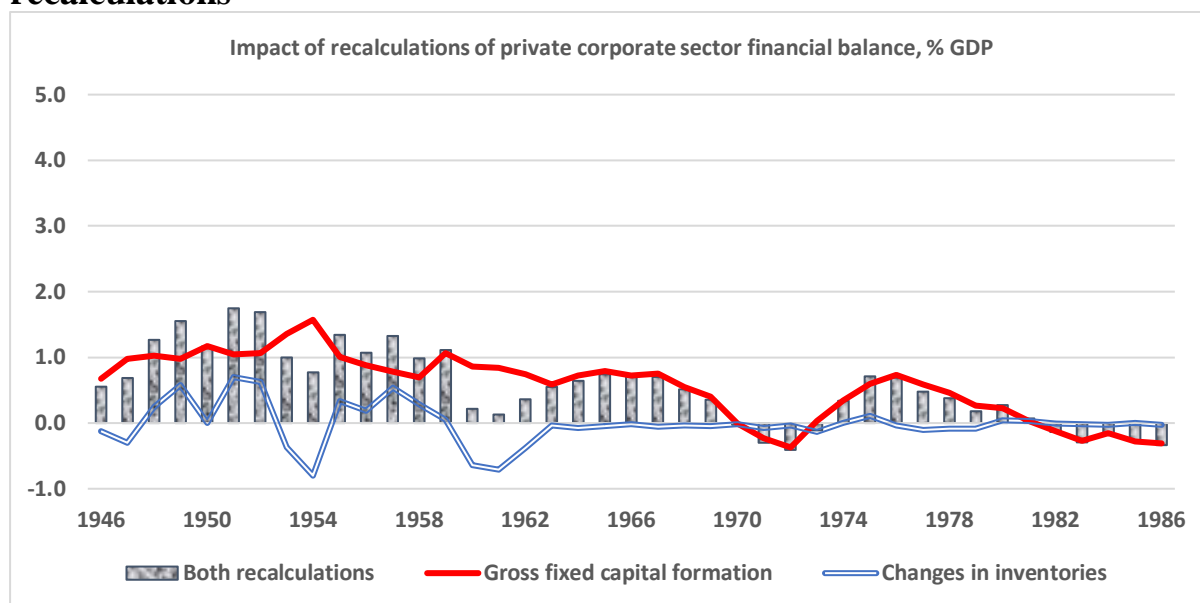**Table D1: Changes in inventories: different vintage estimates for 1950 and 1951**

£ million, unless stated	Changes in inventories			
Year	Year 1950		Year 1951	
Publication	1997 BB	2001 BB	1997 BB	2001 BB
Whole economy of which:	-210	-210	575	575
General government	-96	-96	169	169
Public corporations	-15	-14	5	-84
PNFC (or ICC)	-141	432	295	916
Household sector	42	-532	106	-426
Per cent stock level*	2.5	-31.7	5.9	-23.9
Per cent GDP	0.3	-4.2	0.7	-3.0

Sources: *UK Economic Accounts* published 2Q 1998; 1997 and 2001 Blue Books ("BB"), Sefton and Weale (1995). Notes: 1997 Blue Book data derived from a combination of *UK Economic Accounts* and Sefton and Weale data (see Martin (2019) for personal sector series). 2001 Blue Book household sector data inferred by identity. Financial corporations inventory changes are assumed to be zero. *1997 Blue Book stock level at the end of the previous year estimated by cumulating backwards the changes in the book value of stocks from the end-1996 personal sector level (1997 Blue Book, p171).

As a sense check comparable to that for stockbuilding, Chart D3 also shows the revisions between the 1997 Blue Book data, crudely backcast before 1963, and the 2001 Blue Book data for PNFC gross fixed capital formation. These revisions do not show the erratic pattern exhibited by the stockbuilding revisions, and stay within a comparatively narrow range of between ½ per cent and 1½ per cent of GDP. The revisions are consistently upwards, seemingly consistent with the widening of the definition of capital expenditure to include intangibles. The upward drift in the revisions seen in Chart D2 before 1960, and especially before 1952, is more questionable. But as a source of concern, this drift is of second order importance compared with the likely material error in the official data for gross fixed capital formation over the same period.

Chart D4, drawn with the same vertical scale as Chart D3, summarises the impact on the private corporate sector financial balance of the recalculations of gross fixed capital formation and stockbuilding in the historic period. The combined revision averages 1¼ per cent of GDP before 1960 and ¼ per cent of GDP in the 1960 to 1986 interval, with variation across sub-periods. The combined upward revision averages ½ per cent of GDP in the 1960s. There are equivalent revisions in the opposite direction for the household sector financial balance.

Chart D4: Impact of gross fixed capital formation and inventory change recalculations

Impact of recalculations of private corporate sector financial balance, % GDP

Legend: Both recalculations; Gross fixed capital formation; Changes in inventories

Sources and notes: see Charts D1, D2 and D3.

c) Capital taxes

A minor change, compared with the Martin (2019) method, improves the derivation of capital taxes attributable to the household sector before 1987. Allowance is now made for the (small) PNFC payments of capital taxes, which are deducted from government receipts. The annual and quarterly PNFC series are taken from the *UK Economic Accounts* published in the second quarter of 2007, the last edition to contain these data before 1987. They match the latest ONS estimates in each period for which the two sources overlap.

d) Net other capital transfers

No change is made to the Martin (2019) historic estimates of private corporate net other capital transfers. In the light of evidence of possible error in official data before 1954, Martin (2019) adopted a compromise solution. Pre-ESA95 data were used for the private corporate sector for the period back to and including 1954, with the household sector series derived residually from the private sector total. Before 1954, the household sector data were backcast by splicing pre-ESA95 personal sector data to the residually derived household sector series, while the corporate sector series was derived residually, thus absorbing any errors in the official private sector record. The 2001 Blue Book provides PNFC data for net other capital transfers from 1948 which are consistent with the pre-ESA95 data in the historic period, and so with the backcast private corporate sector data from 1954.

e) Other capital account items.

The 2001 Blue Book provides PNFC data for the net acquisition of valuables and of non-produced, non-financial assets for 1986, with zero entries beforehand. The same variables are scored as zero or unavailable before 1987 for both financial corporations and households. For these minor items, and in a departure from Martin (2019), households are treated as the residual sector before 1987, with each household sector series derived by subtracting the PNFC and financial corporations data from the relevant private sector total. Errors are thereby created in the household sector accounts to the extent that they incorrectly include transactions that should be scored to the private corporate sector.

The errors are unlikely to be material. The main impact on the household sector account before 1987 comes from the residual calculation of the net acquisition of non-produced, non-financial assets. The private sector total, from which the private corporate data are subtracted, is the complement of public sector data taken from the last available *UK Economic Accounts* prior to ONS data purge in 2011. The full impact compared with the Martin (2019) method, which scored household transactions at zero, is to depress the corporate sector financial balance by less than a ¼ per cent of GDP in the historic before 1980. The average impact in the 1980 to 1986 interval is approximately zero.

f) Summary

As a result of all the changes noted in this Annex, the private corporate sector financial balance has been upwardly revised compared to the estimates in Martin (2019) by an average 1 per cent of GDP before 1960. In the subsequent historic period before 1987, the average revision is close to zero with some variation across sub-periods. An average upward revision of ¼ per cent of GDP in the 1960s is followed by an average revision close to zero in the 1970 to 1986 interval. Table D2 provides details.

Table D2: Revisions compared with Martin (2019) to private corporations financial balance

% GDP	Cause of revision on capital account			
Period mean	Gross fixed capital formation	Changes in inventories	Other	Total
1946-1959	1.0	0.1	-0.1	1.0
1960-1986 of which	0.3	-0.1	-0.1	0.1
1960-1969	0.7	-0.2	-0.2	0.3
1970-1979	0.2	0.0	-0.2	0.0
1980-1986	-0.1	0.0	0.0	-0.1

Sources: Martin (2019), my calculations. Notes: see text.

Annex E: Decomposing the 2014 Blue Book revision to investment income

This annex explains the method used to decompose the 2014 Blue Book revisions to financial corporations other investment income due to the ESA10 method of evaluating DB pensions. Also explained is the way this decomposition is very crudely backcast to 1960.

Under ESA95, investment income attributable to pension scheme members was equal to the actual flow of dividend and interest generated by the pension schemes on their assets (Jones and Matthews, 2014, p6). Capital (or "holding") gains and losses resulting from asset price changes were excluded. The same treatment applied to DC schemes and to the DB schemes on which this annex is focused. The sum of dividend and interest income may be construed as the product of the relevant asset yields and the corresponding level of DB scheme assets in each class. Taking a weighted average across asset classes, the value of investment income of DB schemes at time "t" under ESA95 can be thought of as the product of the average running yield on DB assets, denoted "r_t", and the level of DB assets, denoted, "A_t^{db}". Note that the running yield here is one implied by the flow of income and by the level of assets; the yield is not an independent determinant of the recorded investment income flow.

Under ESA10, the investment income attributable to DC scheme members is counted as it was under ESA95 as the actual flow of dividends and interest generated by the investment of the DC pension schemes assets. But for DB schemes, investment income attributable to scheme members is a fictional flow equal to the product of the discount rate, denoted "d_t", and the actuarial level of DB pension entitlements, denoted "L_t^{db}". The discount rate as defined here is a weighted average of the yield on a long-dated UK government bond for DB schemes that are not the responsibility of government, and, under ESA10 edict, a 5 per cent discount rate for DB schemes that are the responsibility of government. Note that in contrast to the implied running yield defined above under ESA95 accounting, the average discount rate is an independent determinant of the fictional flow of income.

The dating convention is such that the discount rate and running yield can be interpreted either as end-period rates at time "$t-1$", or equivalently, as beginning-period rates at time "t". The same dating convention applies to assets and liabilities. The symbolic derivation here uses beginning-year concepts, so that the products of the discount rate and running yield and the relevant balance sheet series give, by identity, the corresponding investment income series in the same year.

The (downward) revision to the record of other investment income of financial corporations in the 2014 Blue Book due to the changed valuation of DB schemes, denoted "$\nabla OP_{m,t}^{db}$", is given by:

$$\nabla OP_{m,t}^{db} \equiv -\left[d_t L_t^{db} - r_t A_t^{db} \right] \tag{E1}$$

The desired decomposition of identity (E1) can be achieved using two equally valid methods. Under decomposition (1), the term $d_t A_t^{db}$ is added and subtracted and the right-hand side of identity (E1) re-arranged to form:

$$\nabla OP_{m,t}^{db,decomp1} \equiv -\left[d_t \left(L_t^{db} - A_t^{db} \right) + \left(d_t - r_t \right) A_t^{db} \right] \tag{E2}$$

Under decomposition (2), the term $r_t L_t^{db}$ is added and subtracted and the right-hand side of (E1) re-arranged to form:

$$\nabla OP_{m,t}^{db,decomp2} \equiv -\left[r_t \left(L_t^{db} - A_t^{db} \right) + \left(d_t - r_t \right) L_t^{db} \right] \tag{E3}$$

Identities (E2) and (E3) divide the ESA95 to ESA10 downward revision of financial corporations other investment income due to the new treatment of DB pensions into the two parts stated in the main text. The first part comprises the revision due to any underfunding of DB schemes, with balance sheet liabilities exceeding the schemes' actual assets. Decomposition (2) differs from decomposition (1) by scaling the underfunding by the running yield rather than by the discount rate. The second part of the decompositions comprises the revision due to any excess of the discount rate over the running yield: the "yield gap". Decomposition (2) differs from decomposition (1) by scaling the yield gap by the level of DB pension scheme liabilities rather than by the level of DB pension scheme assets.

The interpretation of the underfunding impact is straightforward. Under ESA95 accounting, investment income was confined to actual income generated on the funds' actual *assets*. Under ESA10 accounting, the fictional flow of investment income is calculated with reference to the level of the DB funds' *liabilities*. By definition, liabilities exceed assets in DB schemes that are underfunded. For any given yield, the result compared with ESA95 accounting is an increase in investment income payable by underfunded DB schemes to members.

The background accounting is somewhat more involved. Under ESA10, the underfunded DB pension schemes are deemed to have an additional category of "asset", representing claims on scheme sponsors who are held to be responsible for the schemes' liabilities. In the published accounts, the invented assets are called "claims of pension funds on pension managers", "pension managers" being the unhelpfully ambiguous term used to refer to DB scheme sponsors. The DB

schemes' underfunding claim is a liability of the sponsors in the private (strictly "non-government") and general government sectors. With these invented claims added, the underfunded DB schemes' net worth is zero. Oddly, under ESA10, the claims attract no counterpart flow of interest payable by sponsors to the underfunded DB pension schemes. The resulting missing flow of investment income attributed to underfunded DB pension scheme members comes out of thin air.

The interpretation of the yield gap impact is rather less intuitive. The impact arising from the excess of the discount rate over the running yield is present even in the case of fully funded DB schemes, with liabilities equal to actual assets. Reinsdorf et al. (2014) offer the following helpful rationalisation. They construe the product of the discount rate and the schemes' assets as the "predicted value for the returns on pension investments." In the case of equity investments, for example, the predicted return would include equity capital gains in addition to dividend income. Under ESA95, and under standard national accounting conventions otherwise observed under ESA10, capital gains are not counted as part of income but added instead to wealth. But in its treatment of DB pensions, ESA10 implicitly includes within investment income a predicted value of capital gain. On this interpretation, the yield gap impact is a measure of predicted capital gains on fully-funded DB pension fund assets that are included under ESA10 accounting but excluded under ESA95 accounting.

The main problem to be faced in calculating this decomposition is the absence of data on the DB component of investment income under ESA95 accounting. The published ESA10 tables separate out payments by the financial corporate sector of other investment income "payable on pension entitlements". These payments comprise payments of investment income in respect of both DC and DB schemes. In the ESA95 accounts, by contrast, this type of investment income was subsumed under a general heading of "property income attributable to insurance policy holders". This heading was replaced under ESA10 as "other investment income", of which, confusingly, the investment income attributable to insurance policy holders is a part, alongside investment income payable on pension entitlements and investment income attributable to collective investment fund shareholders.

A variety of calculation methods were explored using published ONS data on ESA10 DB investment income flows and data from the now discontinued "MQ5" survey of "Investment by insurance companies, pension funds and trusts" to calculate ESA95 investment income flows. The ONS used the MQ5 market value of "self-administered" pension funds (SAPF) to calculate the level of DB scheme underfunding (see, for example, Levy, 2017, pp. 10-11, Figure 6). MQ5 also included data for SAPF dividend and interest income. It was found that it was possible quite accurately to represent ESA95 investment income using MQ5 data

of a similar vintage to the 2014 Blue Book dataset for the early part of the period of interest that begins in 1987. However, the calculations resulted in marked residual errors in the latter part of the overlapping period, common to both the 2013 and 2014 Blue Books, which ends in 2012. The unexplained residual errors in the calculations averaged ½ per cent of GDP in the 2003 to 2012 interval, in contrast to a zero average in the 1987 to 2002 interval. In 1987, the residual calculation error was minus 0.1 per cent of GDP; in 2012 it was 0.5 per cent of GDP. This means that these direct calculations of the revision in the 2014 Blue Book to financial corporations DB investment income failed to square after the early-2000s with the actual revision to financial corporations other investment income.

Very little of the residual calculation error is likely to be due to unobserved revisions to the remaining components of other investment income: those attributable to insurance policy holders and collective investment fund shareholders. As these components are not separately identified in the ESA95 accounts, any revisions to them in the transition to ESA10 cannot be disentangled from the revision to the other investment income category as a whole. However, a comparison, limited to the 2010 to 2012 interval, of the revisions to other investment income in total and those ascribed in ONS advisories to the impact of the new method of evaluating pensions (Davies et al., 2014; James et al, 2014; Jones and Matthews, 2014) reveals that revisions to components of other investment income excluding those relating to pension entitlements were very small, at around plus or minus 0.1 per cent of GDP. The implication is that the MQ5 data cannot be used accurately to represent the ESA95 investment income of DB schemes after the early-2000s, although the same method produces acceptable results in the preceding period beginning 1987. A possible explanation is that the unpublished DB investment income data that are embedded in the ESA95 accounts were revised by the ONS in the transition to ESA10 accounting, but only materially after the early-2000s.

The calculations used for the main text proceeded as follows. First, the running yield was derived residually, satisfying the identity:

$$\widehat{r}_t \equiv \frac{\nabla OP_{m,t} + d_t L_t^{db}}{A_t^{db}} \tag{E4}$$

where $\nabla OP_{m,t} \equiv \nabla OP_{m,t}^{db} + \nabla OP_{m,t}^{oth}$ and "$\nabla OP_{m,t}^{oth}$" denotes 2014 Blue Book revisions, believed to be small, to components of other investment income excluding those relating to pension entitlements. Identity (E4) locates all the calculation error in the definition of the running yield, given estimates of DB scheme assets and of the investment income arising from DB schemes under ESA10 accounting.

As the two decompositions (E2) and (E3) are equally valid, the two impacts resulting from underfunding and the yield gap are calculated by taking averages:

$$\triangledown OP_{m,t}^{db,undefunding} \equiv -\frac{\left(d_t + \widehat{r}_t\right)\left(L_t^{db} - A_t^{db}\right)}{2} \tag{E5}$$

$$\triangledown OP_{m,t}^{db,yieldgap} \equiv -\frac{\left(d_t - \widehat{r}_t\right)\left(A_t^{db} + L_t^{db}\right)}{2} \tag{E6}$$

Data sources and construction for the period beginning 1987 are described below.

Data for DB scheme liabilities are taken back to 1997 from the available pension entitlements data presented in the 2014 Blue Book-consistent analysis by Jones and Matthews (2014) for non-government sponsored schemes and from ONS (2016) for government sponsored schemes. The ONS (2016) entitlements data for non-government DB schemes are a close match for the Jones and Matthews (2014) data. Discount rate data presented in ONS (2019b) and consistent with those that can be inferred from Jones and Matthews (2014) and ONS (2016) can be combined with the investment income series in ONS (2016) to back out DB liability data for end-1996. These backed out estimates are spliced to the selected 1997 values of DB pension liabilities.

Before 1996, 2014 Blue Book DB pension liabilities data are not available and have to be estimated. They were derived as the sum of the constructed DB pension assets series, explained below, and the ONS series for underfunding consistent with the 2014 Blue Book dataset. The underfunding series is crudely backcast to end-1986 by scaling back the first quarter 1987 value by the rate of increase observed between the first and second quarters of 1987.

Data for total DB scheme assets are derived back to 1996 by deducting the ONS series for underfunding from ESA10 DB pension scheme liabilities. Before 1996, the constructed DB asset series is held constant at its 1996 share of the market value of assets of self-administered pension funds presented in MQ5. The comparison suggests, as expected, that SAPF were specialised in the provision of DB pensions, with only a small part of their business concerned with DC pensions. The levels of SAPF assets in DC pension business implied by these calculations, which enforce consistency with the 2014 Blue Book data, nevertheless differ from the MQ5 series for the outstanding value of SAPF investment in insurance managed funds, insurance policies and annuities.

Data for ESA10-consistent investment income on DB schemes are calculated as the product of the beginning-year discount rates and beginning-year DB pension scheme liabilities, distinguishing between non-government and government sponsored schemes. By construction, the results closely match those presented in ONS (2016) available from 1997 and, allowing for a mistiming of their calculated data, also those for non-government sponsored schemes presented in Jones and

Matthews (2014). The weighted average discount rate is constructed from the relevant DB pension schemes' liability shares, with the division between non-government and government DB schemes before 1996 held constant at end-1996 calculated shares.

Backcast before 1987

An attempt was also made to estimate equivalent series before 1987 back to 1960. This exercise was so fraught with difficulty that the outcome can be regarded as no more than a best guess. The sources of data and methods of construction for the period before 1987 are described below.

Discount rate

ONS (2019b) provides private sector discount rate data back to the first quarter of 1984. In the ESA10 Supplementary table on pensions, the discount rate is equated with the FTSE Actuaries 15-year UK government bond yield on the 31st December each year (ONS private correspondence, November 2019). However, ONS (2019b) warns that its earlier discount rate figures are modelled, effectively backed out from the ONS estimates of "investment income and entitlements for private DB schemes". Based on a comparison with a selection of monthly (end and average) 10-year and 20-year bond yields provided in the estimable Thomas and Dimsdale (2017) dataset, the December spliced average month 10-year bond yield series was chosen as the closest fit to the end-year ONS data before the period covered by the Supplementary table. The average difference between the two series is zero. The 10-year bond yield series is used with a small alignment adjustment to calculate a fourth quarter 1983 figure, using the first quarter 1984 ONS data, and used without adjustment before 1983.

The calculation of the weighted average discount rate assumes that the pension liabilities of DB schemes for which government is held responsible stay at a fixed (estimated end-1996) share of the total. This share (23 per cent) is within a rounding error of the figure used in Martin (2019) to calculate the weighted average discount rate as far back as 1952. The 1952 figure was based on the share of Local Government superannuation funds in non-insured scheme pension fund assets and on the assumption that the schemes were fully funded.

Running yield

Dividend and interest income data as a proportion of outstanding DB assets are estimated by aligning the running yield of life assurance and pension funds (LAPF), using pre-ESA95 data, to a running yield calculated directly from MQ5 data.

The MQ5-derived running yield data can be calculated from end-1983. Dividend and interest income data stop short in 1992 but can be inferred back to 1984 from SAPF dividend, interest and rent income calculated residually from SAPF total
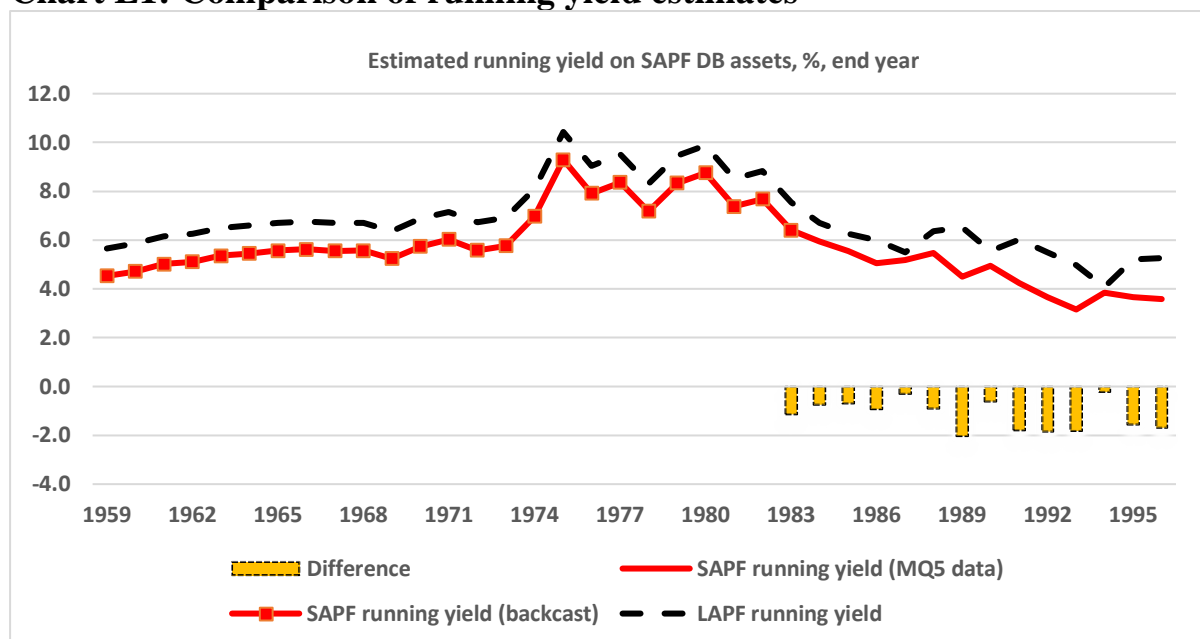
income less the sum of contributions net of rebates, transfers from other pension schemes and other income not otherwise classified. Missing MQ5 data for rent income in 1984 and 1985 are crudely backcast assuming rents form a constant share of total dividend, interest and rent income. Minor interest and rent payments are subtracted.

To calculate the running yield, rent income is deducted from the combined total of dividend, interest and rent income to conform to the ESA95 revised definition of "rent", part of ESA95 property income. There is a degree of uncertainty concerning the exact treatment of rent income on buildings under ESA95. It is assumed that the following account provided by Brueton and Thorp (1998) applies. Under pre-ESA95 accounting, rent on land was included with rent on buildings, and the land on which they stand, as a component of value added. Under ESA95, the term "rent" was redefined to comprise rent on land (mainly agricultural land) and rent on sub-soil assets. Most other payments on land and buildings together were regarded as composite payments for services such as those for housing. As most rented buildings could not be separated in any meaningful way from the land on which they stood, the whole payment was treated as "rental payments for services". While it is possible to exclude rent from SAPF income receipts in the MQ5 dataset, it is not possible similarly to adjust the combined total of payments of interest and rent, but the amounts involved are of second-order importance. The running yield on SAPF assets is assumed not to depend on the split between DB and DC pension business.

To calculate the running yield before 1983 use is made of pre-ESA95 data for life assurance and pension funds. Rent, dividends and interest receipts are taken from the equivalent of Table 4.10 in the 1997 Blue Book. Interest receipts in these accounts are measured net of payments (CSO, 1985, paragraph 6.15, p48). Data missing from the electronic dataset before 1966 are taken from the ESCoE archive of facsimiles of hardcopy Blue Books published from 1971 to 1976. Balance sheet data for the LAPF liability category "life assurance and pension funds" are taken from Table 12.7 in the 1997 Blue Book. The liability data are taken to be equivalent to the market value of LAPF insurance and pension funds. Data missing from the electronic dataset before 1982 are spliced back to 1959 using the (also spliced) series for the insurance and pension assets of households in Al-Hamad (2020).

Chart E1 compares the SAPF and LAPF running yields derived from MQ5 and pre-ESA95 data. During the overlapping interval, 1983 to 1996, the SAPF yield which excludes rent is below the LAPF yield which includes rent. The size of the difference varies but settles down in the earlier part of the overlapping period to about 1 percentage point. To backcast the SAPF yield before 1983, the LAPF yield is adjusted down in each year by the last observed difference in 1983.

Chart E1: Comparison of running yield estimates

Sources: MQ5; Blue Books: 1971 to 1976 and 1997; Al-Hamad (2020); Thomas and Dimsdale (2017). Notes: The backcast SAPF running yield is equal to the LAPF running yield adjusted for the difference between it and the SAPF running yield derived from MQ5 data in 1983.

DB assets

Data for the market value of self-administered pension funds are available from the MQ5 electronic dataset back to 1962. Missing data back to 1959 are derived by splicing the MQ5 series to the backcast pre-ESA95 LAPF series for life assurance and pension funds. The DB share of the market value of self-administered pension funds is held constant at its estimated end-1986 level.

DB liabilities

Official data for the liabilities of non-government sponsored schemes in the ESA10 Supplementary table on pensions rely on the "full buy-out" actuarial measure shown in the *Purple Book* published by the Pension Protection Fund (PPF). The full buy-out liabilities are modelled by the PPF to convert them from the ("s179") basis on which the raw data are supplied by DB scheme actuaries following general regulatory guidance. Data for government-sponsored schemes rely on valuations by the Government Actuary's Department (GAD). Data before end-2009 are modelled by the ONS.

A long-run time series using the same methods of valuation does not exist. The source that comes closest is Blake and Orszag (1999). Their data for household pension entitlements run back to 1948 and, before 1993, are benchmarked to the value of accrued pension rights presented in a number of GAD surveys. The GAD

valuations allow for the future earnings of active scheme members but not future accrual of pensionable service, a method of calculation comparable to the projected benefit obligations approach underpinning the Supplementary table data. In other respects, the ONS and GAD-Blake-Orszag datasets are dissimilar.
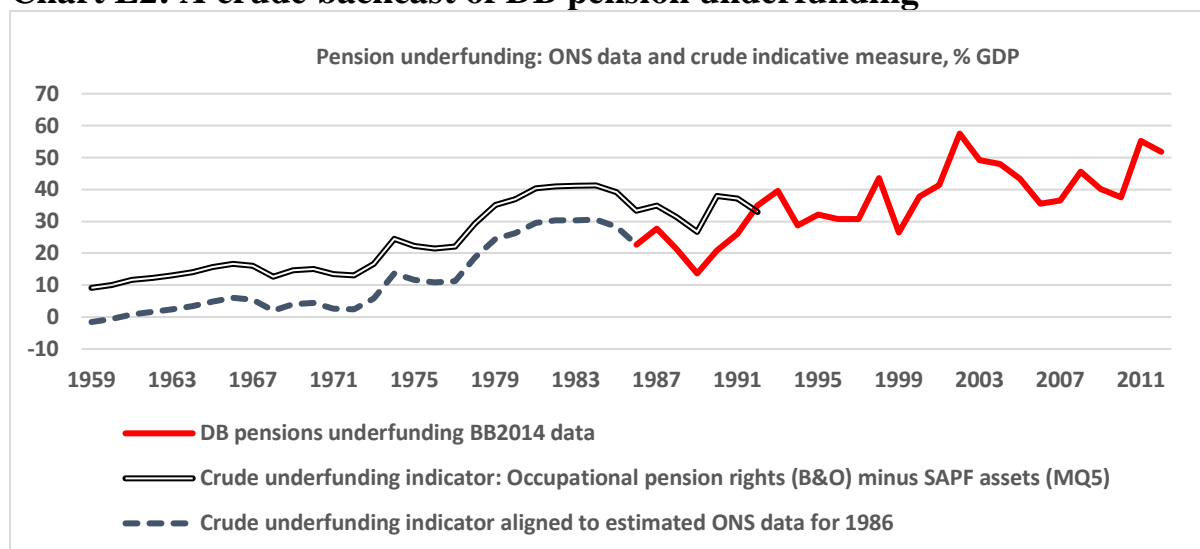
The GAD figures include pension rights arising from unfunded schemes, typically found in the public sector, as well as DB and DC pension rights arising from funded schemes. Rights in unfunded schemes are excluded from the core national accounts data, although estimates are available in the Supplementary table on pensions ("column G"). The sums involved are large. Pension entitlements in unfunded schemes at end-2009 were a third of all DB and DC pension entitlements excluding social security (Levy, 2018a). Other differences arise because actuarial methodology has changed over the period of interest since 1960. Bond yields are now more commonly used for discounting purposes, replacing the practice of using a partly equity-based discount rate for liabilities (see, for example, Cowling et al., 2005; Davis, 2004). The PPF full-buy actuarial measure reflects the asset-liability matching practices of insurance companies, resulting in the use of a discount rate based on bond yields. The GAD estimates in later years assume that the future earnings of members grow less quickly than the discount rate by a fixed amount. Other differences may arise from measurement error. The GAD estimates in the 1960s and 1970s are derived using much less precise methods than later proved possible while the scalars used by Blake and Orszag to align their estimates with the benchmarked GAD valuations have to be interpolated and backcast.

DB underfunding

Chart E2 constructs a very crude indicator of underfunding by subtracting the value of SAPF assets from the Blake and Orszag (1999) pension rights estimates. Apart from the last observation in 1992, the crude indicator exceeds the ONS measure of underfunding available at the time of the 2014 Blue Book. Such an excess might be expected as the Blake and Orszag data include the pension rights of members of unfunded schemes and entitlements in insurers' DC schemes. The movements in the crude indictor and official series in the short 1986 to 1991 interval are not so dissimilar, however.

The chart shows a rough-and-ready backcast of the ONS ESA10-consistent underfunding series that can be constructed by deducting from the crude indicator the value of its excess over the estimated ONS figure in 1986. This excess is equivalent to 10¾ per cent of GDP, a little smaller than the average excess for the 1986 to 1991 interval as a whole of 11½ per cent of GDP. Compared with later periods, the implied level of underfunding is notably smaller in the 1960s.

Chart E2: A crude backcast of DB pension underfunding

Sources: Blake and Orszag (1999), MQ5, 2014 Blue Book, *UK Economic Accounts* published 2Q 2015 and 4Q 2019. Notes: see text.

Abbreviations and acronyms

BPM6: IMF's Balance of Payments and International Investment Position Manual, Sixth Edition.

CSO: Central Statistical Office.

ESA95 & ESA10: European system of national and regional accounts, 1995 & 2010.

ESCoE: Economic Statistics Centre of Excellence.

EU: European Union.

FDI: Foreign direct investment.

FISIM: Financial intermediation services indirectly measured.

HMSO: Her Majesty's Stationery Office.

IARIW: International Association for Research in Income and Wealth.

ICC: Industrial and commercial companies (the pre-ESA95 national accounts term for PNFC).

ICPF: Insurance corporations and pension funds.

IMF: International Monetary Fund.

LAPF: Life assurance and pension funds (the pre-ESA95 national accounts term for ICPF).

MQ5: ONS survey of investment by insurance companies, pensions funds and trusts.

NBER: National Bureau of Economic Research.

NIESR: National Institute of Economic and Social Research.

NPISH: Non-profit institutions serving households.

ONS: Office for National Statistics.

PNFC: Private non-financial corporations.

PPF: Pension Protection Fund.

PSAT: Public sector finances analytical tables.

R&D: Research and development.

SAPF: Self-administered pension funds.

UK: United Kingdom.

US: United States of America.

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