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GENERATIONAL WEALTH ACCOUNTS: DID PUBLIC AND PRIVATE INTER-GENERATIONAL TRANSFERS OFFSET EACH OTHER OVER THE FINANCIAL CRISIS?*

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We develop Generational Wealth Accounts (GWA): the first set of balance sheets, by generations, to include all human capital, tangible wealth, financial wealth, and transfer wealth, and the uses to which these are put, and employ them to quantify inter-generational transfers and the sustainability of consumption. Consumption plans in the UK public sector worsened over the financial crisis and are unsustainable; private sector plans improved, and are now almost balanced. Increases in private capital transfers to the young offset the effect of increased public debt. House price increases shifted resources from young to old but had little effect on sustainability.

It has often been argued that younger generations will carry an outsize share of the cost of the financial crisis. Not only did the crisis lead to an increase in public debt (which will be serviced largely by the young), but since the crisis the young have benefited far less from the significant increase in private-sector wealth (which predominantly benefited the old). Yet this analysis ignores the ability of the generations to share resources with each other through inter-generational transfers. Up to now, the academic literature has only focused on individual components of these transfers (those through the public sector; or those through bequests) but has not integrated them into a single consistent framework. As a result, we do not have a comprehensive view of how much living generations transfer to or from future ones, how these transfers are made and whether they are sufficient to support sustainable levels of consumption for future generations, or how all these transfers respond to macro-economic shocks such as the financial crisis. This is the focus of this paper.

Figure 1 illustrates why it is necessary to examine inter-generational transfers at the level of the whole economy. Panel (a) shows that the public-sector net worth of the UK has fallen from just below 70% of trend GDP to less than −30% over the last thirty years, largely due to increases in public debt. Yet, over the same period, the net worth of the UK private sector has risen from 350% to near 500% of trend GDP. Much of this growth in private wealth is likely due to life-cycle effects in an ageing population. But a substantial fraction will be bequeathed to future generations. It therefore seems plausible that increases in bequests may at least partly compensate the young for the rise in public-sector debt. But whether this is actually so, and by

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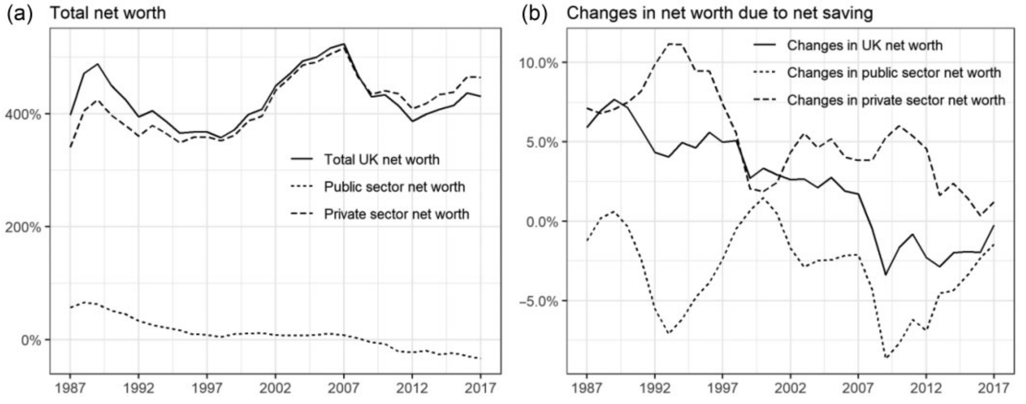

Fig. 1. *Net Worth of the Public and Private Sectors and the UK Total Economy 1987–2017 as a Percentage of Trend GDP.*

Source. UK National Accounts. The public sector is defined as general government plus public, non-financial corporations, and the private sector is the sum of all other sectors that comprise the UK total economy. The series 'Total net worth' in panel (a) are sourced from the UK National Balance Sheet, Table 9.1, ONS (2018); the series 'Changes in net worth due to net saving and capital transfers' in panel (b) are sourced from the UK National Accounts, Table 1.7.7, ONS (2018). Note that this measure of savings excludes capital gains, which are included in panel (a). All series are presented as a percentage of UK trend GDP at market prices. Trend GDP is the exponential of the best linear fit to log GDP over this period; but the charts are insensitive to the choice of detrending approach.

how much, is still an open question. Indeed, panel (b) also suggests that changes in public- and private-sector net worth are offsetting over shorter horizons as the changes are strongly negatively correlated.

In this paper, we develop and present generational wealth accounts (GWA) in order to provide an integrated framework for studying inter-generational transfers. GWA allow us to measure how much current generations are likely to leave future generations, not only through the public sector but also through the private sector, and then whether as current or capital transfers (bequests and inter vivos gifts). We then show how these accounts can be used to assess the aggregate sustainability of the consumption plans of current and future generations. We calculate GWA for the UK over the period 2005–15 and use the results to measure how inter-generational transfers and sustainability changed in response to the financial crisis.

The GWA employ the framework of the national transfer accounts (NTA) of Lee and Mason (2011)[1] to extend the public-sector generational accounts (GA) of Auerbach *et al.* (1991) to the whole economy. GWA are a balance sheet for a given year of the present value of all resources (assets) and uses (liabilities) belonging to each generation. They include human capital, all tangible forms of wealth (real estate, financial wealth) and transfer wealth—the capitalised value of public and private inter-generational transfers (Willis, 1983 and Lee, 1994). We capture cohort differences by disaggregating age, period and cohort effects using a modification of Deaton and Paxson (1994).[2] Using an inter-temporal budget constraint for each generation, we then calculate

[1] The NTA measure inter-generational transfers within a population in a given year. They include public and private transfers, but only focus on current transfers (so ignore capital transfers and bequests). NTA have been calculated for around fifty countries. See United Nations (2013) and Lee and Mason (2014) for details of the approach. A database of results can be found at www.ntaccounts.org.

[2] We thank two anonymous referees for suggesting that we allow for cohort effects in the base case of our analysis.

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a savings gap (SG), equal to the difference between the present value of that generation's available resources and the uses to which those resources will be put.

In GWA, the sustainability of the generational consumption plans is tested through two inter-temporal budget constraints: one for the private sector and one for the public sector. The private-sector constraint is that the economy's aggregate SG (defined as the sum of all living and unborn generations' SGs) must equal zero. If this constraint is satisfied, the capital surpluses of some generations are sufficient to cover the deficits of others, and the private sector has sufficient total resources to cover the consumption plans of all generations. We therefore use the aggregate SG as our measure of the distance of the private sector from sustainability.

The GWA's public-sector inter-temporal budget constraint is the same as the constraint at the core of GA. Like them, we label any shortfall in the public sector as the fiscal gap (FG) and argue that it measures the distance of the public sector from sustainability. We call the sum of the aggregate SG and the FG the consumption gap (CG) and show why it is a natural measure of the distance of the whole economy from sustainability. Unlike simpler measures, such as the national savings rate, the CG takes account of future demographic development, public and private assets and liabilities, and future transfer flows in both the public and the private sectors.

Our first main finding is that while private-sector consumption plans are very close to being sustainable, the public sector is unsustainable, and that therefore aggregate consumption plans are unsustainable too. In the private sector, the consumption plans of the unborn are supported by large transfers from living generations, whereas in the public sector the living pass deficits to the unborn. Although older generations have large capital surpluses (negative SGs: their resources exceed the present value of their future consumption by £4,249 billion), younger living generations and the unborn are in the opposite position (positive SGs; younger living generations of £2,465 billion; the unborn of £1,700 billion; a total of £4,165 billion). This means that the aggregate SG is close to balance, but only because bequests or inter vivos capital transfers shift the capital surpluses of the old to the young and the unborn. By contrast, in the public sector, we find that the older and younger living generations are net recipients of public transfers (the present value of their public consumption and the cash transfers they receive from the public sector exceed the present value of their taxes), but middle-aged living generations are net contributors to the public sector. However, net receipts of the older and younger living generations exceed the net contributions of the middle-aged generations by £921 billion, a shortfall that is transferred to the unborn. As the unborn are also projected to be in net receipt from the public sector by £466 billion, and there is an accumulated public-sector debt resulting from past spending and revenue of £1,986 billion, this leaves a sizeable FG in public-sector finances. Together, the SG and FG imply that aggregate consumption plans are unsustainable (the CG is large, £3,834 billion or 199% of GDP). A cut of 8.3% of the Present Value (PV) of all future public and private consumption would be needed to restore balance.

Our second main finding relates to the offsetting nature of changes in public and private transfers over the financial crisis. We find that between 2005 and 2015, the FG increased sharply, reflecting a worsening in public-sector finances. In large part, this was a result of the fiscal expansion following the financial crisis in 2008. In contrast, we find that over this period the old increased their asset holdings substantially, but, as we estimate they will only consume around 20% of this increase, the balance will be passed to the young. Overall, the deterioration in the sustainability of the public sector, although predominantly carried by the young, will be

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more than offset by a rise in private capital transfers down the generations.[3] In our terminology, the aggregate SG fell by enough to offset the entire change in the FG. The CG was therefore marginally *lower* in 2015 than it was before the crisis in 2005, and the sustainability of aggregate consumption improved over the period.

To the best of our knowledge, this finding is new: no analysis of inter-generational interactions up to this point has simultaneously accounted for all intergenerational transfers—public and private, capital and current—in the context of population ageing. For example, many researchers have used GA[4] to argue that because of the ageing of the population and the resultant rising fiscal demands, we will be leaving substantial public debts to our descendants that may be damaging to their well-being in both the UK and the United States,[5] a finding that our analysis of the public sector confirms. Others have examined sustainability in the private sector under the assumption that each cohort is self-sufficient, i.e., ignoring bequests and inter vivos transfers, either by trying to explain the aggregate savings rate[6] or focusing more specifically on whether the older working generations are saving enough to support their retirement.[7] However, bequests are found to be substantial, and in addition there is evidence that inter vivos capital transfers (e.g., lump sum payments from parents to children, to assist children in buying a house, say) may be badly under-recorded in surveys.[8]

We argue that because all of these prior analyses ignore elements of the possible offsetting nature of public- and private-sector transfers,[9] they are incomplete. This is despite the long literature going back to Ricardo (1951) stressing precisely this point. Since Barro's (1974) formalisation of Ricardo's equivalence proposition, there has been considerable empirical work on whether transfers in the public sector are offset by transfers in the private.[10] De Mello *et al.* (2004) discussed some of the difficulties with these empirical tests. They highlighted that the tests are performed on savings rates from national accounts and therefore struggle to incorporate changes in levels of wealth. They also mentioned the difficulties in adjusting for corporate payout policy, the sometimes marginal distinction between consumption goods and investment goods and the impact of demographic changes. Though we do not claim to have a panacea—far from it, as we need to make some alternative assumptions, outlined below—we do claim that GWA suffers less from these particular difficulties.[11]

[3] As discussed later, we recognise that this has important implications for intra-generational equity. However, the focus of this paper is on measuring inter-generational sustainability, and we leave considerations of fairness to future work.

[4] See Cardarelli *et al.* (2000) and the OBR (2017) for GA in the UK, Raffelhuschen (1999) and European Commission (2016) for Europe and Kotlikoff *et al.* (1999) for a global view.

[5] See, for example, OBR (2016) for the UK and Gokhale *et al.* (1999), Batini *et al.* (2011), Government Accountability Office (2018), Congressional Budget Office (2019) for the United States.

[6] Gokhale *et al.* (1996), Attanasio and Banks (1998) and Khoman and Weale (2008) being prominent examples.

[7] See Scholz *et al.* (2006) and Poterba (2014) for the United States. Munnell *et al.* (2018) did not deal directly with bequests.

[8] See Karagiannaki and Hills (2013), Karagiannaki (2015), Crawford and Hood (2016), Atkinson (2018) for the UK and Wolff (2002), Munnell and Sundén (2004), Hurd *et al.* (2011), Wolff and Gittleman (2014) for the United States.

[9] Buiter (1997) makes the point specifically in a critique of generational accounting. See Cutler (1993) and Diamond (1996) for similar criticisms.

[10] See, for example, the surveys of Seater (1993), Elmendorf and Mankiw (1999) and Ricciuti (2003), which empirically test whether the private-sector behaviour offsets any fiscal expansion or contraction of the public sector. More recently, de Mello *et al.* (2004) and Röhn (2010) found evidence of 'partial' equivalence on data from all OECD countries.

[11] A separate, but related, literature concentrates more on the inter-generational impact of the great recession on the different generations. See, for example, Hur (2018), Peterman and Sommer (2019), Glover *et al.* (2020). However, their focus is predominantly on the public sector and particularly on the ability of social security to share risk across the generations.

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While, in principle, GWA could be calculated for subgroups of each cohort (and even for individuals), in this paper we use a representative agent for each cohort to focus on aggregate results. We therefore abstract from intra-cohort heterogeneity in both public- and private-sector inter-generational transfers. While we acknowledge the importance of this issue, especially in the context of the current high levels of inequality relative to the 1980s or 1990s,[12] we believe it is also important to understand the distribution of resources across generations. As this paper shall demonstrate, there are significant flows across the generations and any policy aimed at reducing inequality must take account of this generational interconnectedness. We leave to future work an examination of intra-cohort inequality within this context.

The structure of this paper is as follows. The next section provides the theoretical framework underlying GWA, followed by a section discussing the data and methods we use for their estimation. The fourth section reports our results, and the final section concludes. To improve the readability of the paper, we relegate technical details, including robustness checks, to online appendices.

1. Theoretical Framework

We start this section by defining the reference and scope of the GWA. We then use the lifetime inter-temporal budget constraint of each representative individual to define the SG of their generation. Next, we develop the framework for private generational accounts and integrate these with the public generational accounts and the FG measure of Auerbach *et al.* (1991). We use the inter-generational budget constraints of the private and public sectors to show how the SG and the FG respectively measure the distance of the public and private sectors from sustainability, as well as to show why the CG measures the aggregate sustainability of the whole economy. Details of data and estimation are left to Section 2.

1.1. *Reference and Scope*

Individuals are the reference for GWA, not households, and so all flows must be allocated to individuals. Likewise, we examine all resource flows from the point of view of the individual—so cashflows or services received by individuals (denoted with a superscripted plus) have a positive sign and payments made (denoted with a superscripted minus) have a negative sign. We abstract from intra-generational inequality by using a representative agent for each generation. A generation comprises all residents of the country that were born in the same year,[13] so the total over all living generations is the resident population. We index generations by their year of birth, k, and set the index to 0 in the base year of the GWA. So unborn generations will be labelled $k = 1, 2, \ldots$ and living generations will be labelled $k = -\omega, -\omega + 1, \ldots, 0$, where ω is the oldest age that individuals are assumed to live to. We denote by $\rho^{r}_{k,t}$ the demographically

[12] See Burkhauser *et al*. (2016) for an examination of trends in inequality in the UK since the mid-1970's. There was little or no increase in inequality in the period 2005–15. Piketty *et al*. (2018) develop distributional national accounts in which they document increasing levels of intra-cohort inequality in the US.

[13] Thus, in a given year a generation includes all immigrants born elsewhere but now resident in that year, and excludes all emigrants born in the country but no longer resident in that year. This treatment is consistent with the definition of Net National Income (NNI)in the System of National Accounts (SNA).

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adjusted discount factor for generation *k*,

$$\rho^r_{k,t} = \frac{N_{k,t}}{N_{k,\max(0,k)}}(1+r)^{-t},$$

where $N_{k,t}$ is the size of the resident population in year t of the cohort born in year k. For $t < k$, $N_{k,t} = 0$. Here $\rho^r_{k,t}$ takes account of the time value of money between time 0 and t, as well as the demographic development of cohort k over this period due to mortality and migration.

The scope of the GWA is the same as the scope of the system of national accounts (SNA).[14] We have only two sectors—public and private. Public-sector flows are denoted with a superscript g (for government) and private-sector flows with an h (for household sector[15]). How we map items in the SNA to each sector is discussed in the section on data and methods.

1.2. *Public- and Private-Sector Generational Accounts*

To retain consistency with Lee (1994), we define the private generational account, $ga^h_{k,0}$, as the demand for real and financial assets to support life-cycle consumption, after accounting for public and private transfer wealth; so

$$ga^h_{k,0} = \underbrace{\left[\overbrace{\sum_{t=0}^{\omega+k} c^g_{k,t}\rho^r_{k,t}}^{\text{PV of public consumption}} + \overbrace{\sum_{t=0}^{\omega+k} c^h_{k,t}\rho^r_{k,t}}^{\text{PV of private consumption}} - \overbrace{\sum_{t=0}^{\omega+k} y^l_{k,t}\rho^r_{k,t}}^{\text{human capital}}\right]}_{\text{life-cycle demand for assets}}$$

$$- \underbrace{\left[\overbrace{\sum_{t=0}^{\omega+k}(\tau^{h,+}_{k,t} - \tau^{h,-}_{k,t} - \tau^{h,RoW}_{k,t})\rho^r_{k,t}}^{\text{private transfer wealth}} + \overbrace{\sum_{t=0}^{\omega+k}(\tau^{g,+}_{k,t} - \tau^{g,-}_{k,t})\rho^r_{k,t}}^{\text{public transfer wealth}}\right]}_{\text{transfer wealth}}, \qquad (1)$$

where the flows $c^g_{k,t}$ and $c^h_{k,t}$ are the public and private consumption, respectively, and $y^l_{k,t}$ is the labour income of the representative member of generation k in year t. Public consumption consists mainly of age-specific public expenditure on education and health, as well as expenditure on public goods such as defence and the maintenance of law and order. We divide transfer wealth into private and public transfer wealth. Private transfer wealth is the present value of future private transfers received from residents (transfers received by the representative member of generation k in year t are denoted $\tau^{h,+}_{k,t}$) less private transfers paid to residents (denoted $\tau^{h,-}_{k,t}$),[16] and net

[14] It therefore ignores the use of natural resources, the transmission between generations of intangibles such as language and culture, as well as transfers of time through the household production of unremunerated personal services.

[15] We use h to denote the household sector, as in the UK National Accounts, but stress that the individual is the reference agent in the GWA.

[16] In any year the total private transfers paid by residents to residents must equal the total transfers received by residents from residents, so $\sum_{k=t}^{t+\omega} \tau^{h,+}_{k,t} = \sum_{k=t}^{t+\omega} \tau^{h,-}_{k,t}$. This leaves net transfers to the RoW as a balance in the private transfer system.

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private transfers paid to the rest of the world ($\tau_{k,t}^{h,RoW}$).[17] Similarly, public transfer wealth is the present value of future transfers received by the representative agent from the public sector ($\tau_{k,t}^{g,+}$) less transfers paid to the public sector ($\tau_{k,t}^{g,-}$).[18]

The private generational account must be funded from either personal wealth holdings or capital transfers (bequests or inter vivos gifts) from other generations. These capital transfers will be outflows if wealth holdings are more than is sufficient to fund the account and will be inflows if the wealth holdings are insufficient.[19]

To isolate the impact of these capital transfers, we define the per capita savings gap, denoted $sg_{k,0}$, as the difference between the private generational account and the wealth actually owned by the representative agent of generation k in the base year, denoted $w_{k,0}$; so

$$sg_{k,0} = \underbrace{ga_{k,0}^{h}}_{\text{private generational account}} - \underbrace{w_{k,0}}_{\text{net worth}} .$$

The savings gap thus measures the extent to which the actual asset holdings of a representative member of each cohort fall short of (or, if negative, exceed) their life-cycle demand for assets, after allowing for any transfer wealth. Because transfer wealth only includes current transfers, the savings gap measures the private funding gap of any one generation that must be filled through capital transfers (bequests or inter vivos gifts) from other generations.[20] In the GWA we make no assessment of whether these capital transfers are accidental or desired; we simply quantify their magnitude. Pure life-cycle savers expecting to receive or leave no bequests and with access to perfect annuities markets would have savings gaps of zero at every age.

Note that the private-sector generational account incorporates public transfer wealth. Other than a change of sign (because of our focus on the individual, rather than the public sector), we follow GA in defining the public sector per capita generational account as

$$ga_{k,0}^{g} = \underbrace{\sum_{t=0}^{\omega+k} (\tau_{k,t}^{g,+} - \tau_{k,t}^{g,-})\rho_{k,t}^{r}}_{\text{public transfer wealth}}, \tag{2}$$

which is equivalent to the per capita public-sector transfer wealth.

In these equations, accounting for public consumption requires some care. It must be treated as if there was a financial transfer to the individual ($\tau_{k,t}^{g,+}$) who then uses this transfer to buy the consumption good ($c_{k,t}^{g}$). Public consumption is therefore both a resource and a use, nets out in the individual's inter-temporal budget constraint and does not affect their savings gap, but still enters into the definition of public transfer wealth and the public-sector generational account (2).

[17] There is insufficient information to break down transfers to the RoW into received and paid. We therefore simply allocate the net transfers paid, after splitting them between public and private. Private transfers are predominantly net remittances to families abroad.

[18] Note that this excludes net public transfers to the RoW, which are pension or social benefits paid to individuals abroad plus transfers or contributions to other countries and international institutions such as the EU, the IMF or NATO, less any such transfers received. These are paid for by taxes on residents (or by borrowing), but unlike other forms of public consumption, are not received as a transfer by domestic households. We therefore account for these by capitalising them and adding them directly to the fiscal gap.

[19] In Online Appendix A, we link the private generational account to the within-period flow balance used in the NTA.

[20] This is a different approach to Gokhale *et al.* (1996) who imposed a budget constraint on each generation by assuming that these capital transfers are zero or negligible.

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Note that public transfers to the RoW cannot be treated in this way and are therefore excluded from (2). As discussed in footnote 18, we capitalise these and include them in the fiscal gap directly.

1.3. *The Inter-Generational Budget Constraints and Consumption Sustainability*

To assess sustainability, we make use of the inter-temporal budget constraints for the public and private sectors. We first define the aggregate savings gap at time 0 as the sum of per capita savings gaps across all individuals in all current and future generations:

$$\begin{aligned}\underbrace{sg_0}_{\text{aggregate savings gap}} &= \sum_{k=-\omega}^{\infty} N_{k,\max(k,0)} sg_{k,0}\\ &= \sum_{k=-\omega}^{\infty} N_{k,\max(k,0)} ga^h_{k,0} - \underbrace{\sum_{k=-\omega}^{0} N_{k,\max(k,0)} w_{k,0}}_{\text{private-sector net worth}}\\ &= \sum_{k=-\omega}^{\infty} GA^h_{k,0} - NW^h_0. \qquad (3)\end{aligned}$$

Here $GA^h_{k,0}$ denotes the aggregate private generational account of generation k and NW^h_0 is the net worth of the private sector (equal to the total value of assets held by the living generations, as the unborn by assumption own nothing), both at time 0. Sustainable private consumption plans would require that $sg_0 = 0$. We therefore use sg_0 as a measure of the distance of private consumption plans from sustainability.

Likewise, following GA, the FG is defined as the net public transfer deficit plus the capitalised value of unallocated consumption, in this case net public-sector transfers abroad, less the public-sector net worth.[21] In our notation, it can be expressed as

$$\begin{aligned}\underbrace{FG_0}_{\text{fiscal gap}} &= \sum_{k=-\omega}^{\infty} N_{k,\max(k,0)} ga^g_{k,0} + \underbrace{\sum_{k=-\omega}^{\infty} N_{k,\max(k,0)} \sum_{t=0}^{\omega+k} \tau^{g,RoW}_{k,t} \rho^r_{k,t}}_{\text{net public transfers to RoW}} - \underbrace{NW^g_0}_{\text{public-sector net worth}}\\ &= \sum_{k=-\omega}^{\infty} GA^g_{k,0} + T^{g,RoW}_0 - NW^g_0, \qquad (4)\end{aligned}$$

where $T^{g,RoW}_0$ is the present value of future net public-sector transfers to the RoW. A sustainable public sector would require that $FG_0 = 0$. We can therefore use FG_0 as a measure of the distance of public consumption plans from sustainability.

We define the distance of the total economy from aggregate sustainability, called the consumption gap, as the sum of the savings and fiscal gaps, so $CG_0 = sg_0 + FG_0$. We use this terminology

[21] The FG is now reported annually by the UK (Office for Budget Responsibility, 2017) and US governments (Government Accountability Office, 2018), although definitions do vary slightly. Fiscal gaps are sometimes measured over a finite horizon assuming a terminal debt to GDP ratio. Also, we balance to public-sector net worth and not the public-sector net financial liability, so including the value of non-financial assets held by the public sector.

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to emphasise that if the consumption gap is small, aggregate consumption plans are sustainable, even if some transfer of resources between the public and private sectors may be required at some point in the future to restore fiscal and savings balances.

To see why the consumption gap is a natural measure of aggregate sustainability, use the definitions of $sg_0$and FG_0 from (3) and (4), substitute in the definitions of $GA^h_{k,0}$ and $GA^g_{k,0}$ from (1) and (2), switch the order of the summation for private transfer wealth, noting that, by definition, the aggregate total of private transfers between residents equals 0 in each future year, leaving only net transfers to the RoW, cancel out public transfer wealth, and rearrange to give

$$\begin{aligned} CG_0 &= sg_0 + FG_0 \\ &= \overbrace{\underbrace{\sum_{k=-\omega}^{\infty}\sum_{t=0}^{\omega+k} N_{k,\max(k,0)} c_{k,t} \rho^r_{k,t}}_{\text{PV of total consumption}} + \underbrace{T_0^{g,RoW} + T_0^{h,RoW}}_{\text{PV of current transfers to RoW}}}^{\text{total uses}} \\ &\quad - \underbrace{\left(\underbrace{\sum_{k=-\omega}^{\infty}\sum_{t=0}^{\omega+k} N_{k,\max(k,0)} y^l_{k,t} \rho^r_{k,t}}_{\text{total human capital}} + \underbrace{NW_0^g + NW_0^h}_{\text{national net worth}} \right)}_{\text{total resources}}, \end{aligned} \tag{5}$$

where the present value of future private-sector net current transfers to the RoW is denoted $T_0^{h,RoW}$ and defined as

$$T_0^{h,RoW} = \sum_{k=-\omega}^{\infty} N_{k,\max(k,0)} \sum_{t=0}^{\omega+k} \tau^{h,RoW}_{k,t} \rho^r_{k,t}.$$

Thus, the consumption gap measures the shortfall in total resources needed to fund total consumption plans and net transfers to the rest of the world. We present sg_0, FG_0 and CG_0 as absolute values, adjusted for changes in productivity and prices, and, in the spirit of Blanchard *et al.* (1990), as a percentage of aggregate consumption.

1.4. *Transfers Between the Generations*

A central point of our analysis is transfers between the generations. The three transfer systems we examine are private current transfers, private capital transfers (bequests and inter vivos capital transfers) and public transfers. We focus on transfers between generations born before and after a particular year j, and use the balancing conditions in the transfer systems as a whole to derive

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the following:

$$T_0^h(j) = \underbrace{\sum_{k=-\omega}^{j} N_{k,0} \sum_{t=0}^{k+\omega} \rho_{k,t}^r (\tau_{k,t}^{h,-} + \tau_{k,t}^{h,RoW} - \tau_{k,t}^{h,+})}_{\text{net private transfers to those born after year } j},$$

$$T_0^g(j) = \underbrace{\sum_{k=-\omega}^{j} N_{k,0} \sum_{t=0}^{k+\omega} \rho_{k,t}^r (\tau_{k,t}^{g,-} - \tau_{k,t}^{g,+})}_{\text{net public transfers to those born after year } j} \tag{6}$$

$$\text{and} \quad K_0^h(j) = \underbrace{-\sum_{k=-\omega}^{j} SG_{k,0}}_{\text{net capital transfers to those born after year } j},$$

respectively. In the results, we focus on transfers between the living and the unborn, $T_0^h(0)$, $T_0^g(0)$ and $K_0^h(0)$, partly because this divide marks a logical break in the flow of the generations, partly as it maintains consistency with GA, but also because it emphases the point made in Lee *et al.* (2017) that, in aggregate, the living transfer significant resources to the unborn (though not through the public sector).

2. Data and Methods

In this section, we describe the data and methods we use to estimate the accounts described in the previous section. We first discuss how we obtain, from the national accounts, macro-economic aggregate controls for the income and expenditure components of net national income by sector, then how we use survey and other data to split these aggregates into per capita age-related flows, which we call age profiles, followed by the estimation and projection approaches we use. Our central estimates are based on an age-period-cohort model, although we also report results using a simpler smoothing and projection procedure as a robustness check. We then discuss how we estimate the wealth profile in the base year. The final section discusses the population projections and discount rate.

2.1. *Estimating Macro-Economic Aggregate Controls for Flow Items*

As our focus is on residency, we start with net national income, and its components, obtained from the national accounts (Office for National Statistics, 2018). We collapse the five sectors of the national accounts (government, households, corporations, non-profit institutions serving households (NPISH) and the rest of the world) into three (public sector, private sector and RoW) by piercing the corporate veil and allocating the corporate flows to the private sector,[22] and by splitting NPISH into universities (allocated to the public sector) and other (allocated to the private).[23]

[22] When we split these aggregates by age, we use a profile reflecting individual ownership of the corporate sector, therefore allocating corporate flows to owners of capital.

[23] See HMT (2021) and Student Loan Company (2019) for data on the split.

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Where possible, we follow the incidence assumptions used in GA and national accounting, so taxes are generally incident on those who pay them, and government transfers benefit those who receive them. We therefore assume that corporate taxes are incident on the corporate sector (although we reallocate these to individual owners of capital when we pierce the corporate veil). Exceptions are employer payroll taxes (which we assume are incident on labour), indirect taxes and subsidies on products (incident on consumers), and indirect taxes and subsidies on production (which we split between capital and labour in proportion to their share of national income).

Other adjustments, including the treatment of mixed income,[24] the allocation of indirect taxes less subsidies on products and production, the use of basic rather than market prices, and the derivation of macro-controls for inter- and intra-household private transfers (for which no estimates can be obtained from the national accounts) are discussed in Online Appendix B.

2.2. *Estimating Age Profiles for Flow Items*

In general, we use survey or administrative data to decompose the macro-economic aggregates by age. For some economic flows, this decomposition is relatively straightforward. For example, we estimate the average labour income of an individual of a given age in a given year using the Living and Food Cost Survey (LCFS), our primary data source. We then scale this profile so that, when weighted by the population at each age and summed, the total equals the macro-economic aggregate. For labour income, this rescaling is modest and of the order of 3%; for others, such as consumption of alcohol and tobacco, the scaling was larger. Table B1 in Online Appendix B gives details of each aggregate, the surveys used to break it down by age and the scaling used for each item in 2015.

For more complicated profiles, we follow the approach in the NTA manual (United Nations, 2013). The main difficulties relate to consumption flows recorded at household, rather than individual level (we use a household equivalence scale standard in the NTA project[25]); the assignment of assets and inter-household flows to individual household members (we assume that all assets are owned by the household head, and that inter-household transfers occur only between the heads of different households); the calculation of intra-household private transfers (each household member transfers the surplus (or deficit) between their own income and consumption to the household head); the treatment of flows between households and institutions; and problems arising from the sampling scope of the LCFS. These and more minor issues are dealt with in detail in Online Appendix B.

These profiles, unsmoothed but balanced to macro-economic aggregates, are calculated separately for each year between 1990 and 2015, available at National Transfer Accounts (2021). They are then used to estimate an age-period cohort (APC) model, to which we now turn. The model allows for changes in the ages of entry to, and exit from, the labour force.[26] To aid

[24] Profits of unincorporated businesses where the precise attribution to capital and labour is unclear.

[25] The scale expresses the consumption of household members of different ages as a proportion of the consumption of those over the age of twenty. For children under four, this proportion is 40%. Between ages four and twenty, the proportion increases linearly with age.

[26] Banks *et al.* (2018) documented changes in labour force participation by age and gender using the UK Labour Force Survey. For both men and women, the expansion of tertiary education has meant that, on average, individuals have entered the labour market increasingly later over this period. For women, and for men since 1995, they also reported the trend towards higher participation rates at older ages. Without allowing for these changes, labour income of the recent young would spuriously appear low relative to their antecedents at the same age; a similar but opposite problem would exist for the recent old.

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explication, we deal with the APC approach before discussing our treatment of changes in the length of working life.

We first detrended all unsmoothed profile estimates from 1990 to 2015 by dividing by the average wage of a full-time, employed worker in each year,[27] and fit the following model to these data:

$$\frac{x_{k,t}}{w_t} = \beta^x + \alpha_a^x + \gamma_k^x + \psi_t^x + \varepsilon_{k,t}^x. \tag{7}$$

Here the subscripts k and t are cohort and period; as before, $a = t - k$ is age; $x_{k,t}$ is the (un-detrended) profile in question; w_t is the wage index used to detrend; α^x, γ^x, ψ^x are the age, cohort and period dummies for profile x, respectively, and β^x is a constant.

The well-known issue with APC models is that in addition to dropping a single age, period and cohort dummy to avoid collinearity with the constant term, it is necessary to impose some further identification restriction to avoid collinearity around a time trend as $t = k + a$. Our procedure is to follow Deaton and Paxson (1994) in assuming that the average cohort effects are 0 and that there is no time trend in the cohort effects, but in addition we assume that the average period effect is zero and that there is no time trend in the period effect,[28] so

$$\sum_k \gamma_k^x = 0, \quad \sum_k k\gamma_k^x = 0, \quad \sum_t \psi_t^x = 0 \quad \text{and} \quad \sum_t t\psi_t^x = 0.$$

To improve the stability of estimates, we used a weighted least squares approach by assuming that $\varepsilon_{k,t}^x \sim N(0, (\varpi_a^x \sigma^x)^2)$, where $\varpi_a^x \approx \sqrt{\text{var}(x_{k,t}/w_t | k = t - a)}$ (the equality is not exact because we smooth the weighting function), and estimate a single cohort effect for groups of early and late cohorts, for whom there are not many observations. These cohorts are grouped to ensure that there is at least twenty observations per group, slightly less than the twenty-five observations for each cohort who live through the whole data sample from 1990–2015.

To account for expanding tertiary education and later retirement, before we fit (7) we allow the profiles to shift to the right by introducing entry and retirement breakpoints,[29] labelled $k_i^{x,E}$ and $k_i^{x,R}$, $i = 1, \ldots$. We define the effective age $a^{x,*}(a, k)$ of a generational member as

$$a^{x,*}(a, k) = a + \sum\nolimits_i 1(k \geq k_i^{x,E})1(a < 45) + \sum\nolimits_i 1(k \geq k_i^{x,R})1(a \geq 45). \tag{8}$$

Thus, for example, if we estimate an entry breakpoint in 1975 for the labour income profile, $k_1^{y_L,E} = 1975$, then anyone born on or after 1975 will on average have the same wage at age twenty-six (adjusted for productivity changes) as a twenty-five-year old born before 1975. We then estimate the APC model but using the effective age $a^{*,x}$ rather than actual age $a = t - k$. To ensure that our cohort effect estimates γ_k^x pick up only changes in profiles that are not explained by changes in the start and end of working life, we adopt a two-stage procedure. We first estimate the breakpoints, following Bai and Perron (1998; 2003), by maximising the log-likelihood of (7) but without cohort effects (so setting $\gamma_k^x \equiv 0$). In the second stage we treat these breakpoint estimates as fixed and re-estimate the full model (7) including cohort effects, again by maximising the log-likelihood.

[27] The numbers are scaled by the rise in the average nominal wage from 1990 to 2015; estimated as total compensation of all employees (ONS series, DTWM) divided by the number of employees (ONS Series, MGRZ – MGRQ). This scaling factor of 1.269 is almost identical to the ratio of nominal GDP per capita between 2005 and 2015 of 1.266.

[28] This is permitted by our use of detrended profiles. Removing time trends explicitly improves robustness by reducing the canonical correlation between the blocks of age, period and cohort dummies. We check this assumption by including time dummies in regression (7) and testing their significance.

[29] See Table C1 in the Online Appendix for the breakpoints.

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This procedure provided estimates of the age, cohort and period dummies, a set of breakpoints and a standard error $\{\hat{\beta}^x, \hat{\alpha}^x_a, \hat{\gamma}^x_k, \hat{\psi}^x_t, \hat{k}^{x,E}_i, \hat{k}^{x,R}_i, \hat{\sigma}^x\}$ for each profile x. Detailed results of the estimations can be found in Online Appendix C.

2.3. *Projecting the Age Profiles*

To calculate the GWA, we need a set of age profiles, starting in a base year 0, for each year $t \geq 0$. We used the set of estimates obtained from our estimation procedure as follows:

$$\hat{x}_{k,t} = w_0(1+g)^t[\hat{\beta}^x + \hat{\alpha}^x_{a*} + \hat{\gamma}^x_k + \hat{\psi}^x_t e^{-(\ln 2)t/\theta}], \quad t > 0.$$

Age and cohort effects were therefore assumed to be permanent, but period effects were assumed to decay over time with a half-life of θ years. Because time effects capture business cycle fluctuations (e.g., consumption is pro-cyclical; government transfers are counter-cyclical), we set $\theta = 7.5$ years, around the average length of the business cycle since 1970 in the UK.[30] The base level of the profile grows at rate g, which we set equal to 1.5% p.a., the average growth of labour productivity over the last twenty years.[31] In the projections, we assumed that the breakpoints were as estimated for each profile within our data frame, but that all profiles had new retirement breakpoints at and after age forty-five in (8) for those cohorts affected by future scheduled changes to the state pension age.[32]

As the demographic structure of the population changes, aggregate private transfers paid to residents will no longer balance to private transfers received from residents unless an adjustment is made. We therefore altered the level of each profile equally in each future year to ensure balance, thereby assuming that the demographic burden of changing populations was shared equally between parents and children.[33]

To test the robustness of our results to our baseline assumptions, we compare these results to results based on a simpler, smoothing-based approach. In this alternative, we smooth each profile in each year using a Gaussian kernel smoother to eliminate sampling variation, and project the smoothed end-of-sample profile forward assuming a constant rate of productivity growth g. While simpler than the APC approach, this approach does not distinguish between cohort and time effects, and therefore assumes that all changes in profiles are permanent. Any profile changes are therefore fully capitalised. Results are reported in Online Appendix D.

2.4. *Estimating the Wealth Profile*

As we show in Online Appendix A, our approach does not require age profiles for asset-based flows (such as savings, asset income received or paid, or bequests and other capital transfers), as it deals with these through discounting and the inclusion of the savings gap. However, we *do* need a decomposition of wealth holdings by age in the base year. For our purposes, wealth

[30] Results are not particularly sensitive to choices of θ between five and ten years.

[31] The ONS series for output per hour worked for the UK economy, code LZVB, rose at an average rate of 1.52% p.a. between 1992 and 2012. Alternatively, output per capita (ONS GDP output series ABMI divided by resident population size EBAQ) has risen at 1.54% p.a. over the last twenty years, but has averaged 1.75% p.a. over the last fifty years.

[32] The increase of the SPA to age sixty-six in 2019 is picked up by our estimation procedure (as the affected cohort is forty-five inside our data frame), but we insert further breakpoints linked to the currently scheduled increases in the SPA (to sixty-seven around 2027, and to sixty-eight around 2043).

[33] The vast majority of private current transfers are from parents to their children. Literature on the quality-quantity trade-off suggests that this is not an inappropriate choice (see Lee and Mason, 2010).

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includes financial wealth, real assets such as residential and commercial real estate, and accrued occupational pension rights owned by the cohort. We divide wealth into two categories: housing wealth, gross of mortgage debt, and all other wealth, net of any mortgages. We use the value of assets as reported in various waves of the Wealth and Asset Survey (WAS; ONS, 2019). This is usually, but not always, fair market value or some estimate thereof. Other than state pensions, which are treated as a public transfer received, we treat the three other types of pensions in an equivalent manner, with details available in Online Appendix B.[34] Note that because WAS reports asset holdings at household rather than individual level, we adjust WAS profiles by household headship rates at each age to ensure consistency with our assumption that all assets are owned by the household head.

We balance private-sector worth to the total obtained from the WAS, and public-sector worth to the public-sector net worth obtained from the Whole of Government Accounts produced by HM Treasury (2020). We chose these sources to correctly incorporate the value of unfunded occupational pensions where the government is the employer[35] and the value of fixed assets owned by government.[36] Profiles are available at National Transfer Accounts (2021).

2.5. *Population Projections and Discount Rate*

To project populations, we used the Office of National Statistics' (Office for National Statistics, 2017) principal population projections for the UK. These projections run out to 2114; after which, when necessary, we assume that the total fertility rate (TFR), migration and mortality rates at each age remain constant at their 2114 value. Sensitivity to this assumption is negligible.

We assumed a real discount rate of 5% p.a. This is close to the average return on capital in the UK over the last twenty years (consistent figures on net worth of the UK are only available for twenty years).[37] We discount all future resource flows at this rate. This deserves some comment. First, because the rates of return on fixed income securities are generally lower than the cost of capital, we make the assumption that these are held in zero net supply. This is clearly not true as some UK debt is held abroad, and UK residents hold some foreign debt, but the amounts are close to offsetting. As a result, returns to these securities net out and what matters at the aggregate level is the return on capital. Secondly, financial theory requires that the discount rate that should be applied to a given resource flow depends on how risky it is. Here, because all flows are assumed to grow in line with aggregate productivity, all can be regarded as being equally risky, and should be discounted at the same rate, the aggregate return on capital.[38]

[34] The other three types are funded private pensions, and funded and unfunded occupational pensions for government employees.

[35] Under ESA 2010, these are omitted from the core national accounts as both a liability of the government and an asset of the household. We treat these analogously to funded pensions by assuming that the government issues debt and uses this capital to fully fund these pensions.

[36] In Online Appendix B, we discuss the difference between these estimates of net worth and those in the national accounts. But after adjusting for durables and other small differences, the estimates are in very broad agreement until 2008, and differ by less than 10% afterwards. We discuss the sensitivity of our results to this difference in Online Appendix D.

[37] We calculate the returns to capital as net operating surplus (gross operating surplus, series ABNF in Office for National Statistics, 2018, plus 33% of mixed income, series QWLT, less total capital consumption, series NQAE), plus net property and entrepreneurial income received from the rest of the world, series HMBM, all divided by the total UK net worth, series CGDA. The average over the period 1995–2015 was 5.44%, but between 2002 and 2015 it only averaged 4.62%. We used a discount rate of 5% p.a. as a round number within the likely range of possibilities.

[38] For a detailed discussion of this issue, see Subsection 1.4 of Auerbach *et al.* (1999).

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3. Generational Wealth Accounts for the UK

Table 1 presents the per capita private and public generational accounts for the UK in 2015 in GBP ‘000. The components of the accounts are shown in rows and the different generations in columns, starting with the oldest in the left-most column, leading to the unborn at the far right. Panel A shows the private generational account and the savings gap. This table shows the first estimates of transfer wealth in the context of human capital, consumption and financial wealth. It therefore provides a measure of the inter-connectedness of the generations in a single framework, as well as a comprehensive balance sheet of UK birth cohorts.

The first five rows of panel A show the life-cycle demand for assets and its components. The present value of public consumption (line A) reflects peaks associated with medical spending in old age and education spending for the young. The present value of private non-housing and housing consumption (lines B and C), on the other hand, rise monotonically with year of birth, except at the youngest ages, where private consumption flows are small and discounting lowers the present value of private consumption later in life. Human capital (line D) has a hump-shaped profile with age, reflecting a present value at younger ages that heavily discounts prime age earnings, and low or zero earnings after retirement. The life-cycle demand for assets (line E), the difference between the present value of consumption and human capital, is therefore positive for the very young, falls with increasing age until around age thirty and then rises again, reaching a peak around age sixty-five before falling again. This life-cycle demand for assets must be funded from either transfer wealth, public or private, or financial assets that in turn are either held or transferred from other generations.

The next three rows show the size and composition of transfer wealth by birth cohort. Transfer wealth is significant in magnitude, illustrating the importance of transfer systems in shifting resources over the life cycle and between generations. Furthermore, private transfer wealth and public transfer wealth are of similar order, although private transfer wealth is greater in absolute magnitude than public transfer wealth at most ages. Public transfer wealth (line F) follows the pattern of public spending. Private transfer wealth (line G), on the other hand, reflects the fact that in the UK private transfers flow largely from parents to children, and is therefore negative all ages except the very young and the unborn. Our estimates incorporate the effects of falling fertility, which reduces the costs of future child-rearing. The fact that transfer wealth is positive for the very young has the effect of increasing the economy’s aggregate wealth holdings ceteris paribus.[39]

The private generational account (line I) shows the wealth that each person would need to hold on average at each age to meet that portion of the life-cycle demand for assets not met by transfer wealth. It is positive at all ages, showing that consumption plans cannot be financed by human capital and transfer wealth alone. The next two lines (lines J and K) show actual per capita wealth holdings (net worth) by age in 2015, split into housing and non-housing wealth. These rise with year of birth until retirement age, peaking at £466,000 (= £288,000 + £178,000) for those in their sixties, and then fall monotonically with decreasing age (reflecting the process by which asset holdings are built up during working life).

[39] To understand this, assume that the consumption path is the same whatever the transfer arrangements; reasonable given the small open economy, and accompanying exogenous interest rate, assumption. Transfers down the generations imply younger generations need to borrow less when young and simultaneously save more to be able afford these transfers to the younger generations when older. This unequivocally raises aggregate wealth. The argument is similar in a closed economy, but is more involved as now the interest rate will fall as wealth increases, offsetting some of the need to save and perhaps altering the desired consumption profile; see Willis (1983).

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Table 1. *Private and Public Generational Accounts for the UK, 2015 (2015 GBP thousands).*

	Year of birth										
Age in 2015	Before 1926 90+	1926–35 80–89	1936–45 70–79	1946–55 60–69	1956–65 50–59	1966–75 40–49	1976–85 30–39	1986–95 20–29	1996–2005 10–19	2006–15 0–9	After 2015 Unborn
Panel A: private generational account and savings gap											
A. PV(public consumption)	45	76	109	132	141	141	137	135	148	160	154
B. PV(private non-housing consumption)	32	65	124	193	253	293	305	339	364	322	302
C. PV(private housing consumption)	25	45	70	91	106	112	118	128	126	108	99
D. Human capital	0	0	2	39	230	444	609	667	583	422	369
E. Life-cycle demand for assets (A + B + C − D)	**103**	**185**	**300**	**377**	**268**	**103**	**(49)**	**(65)**	**56**	**168**	**187**
F. Public transfer wealth	56	90	122	122	52	(17)	(52)	(59)	(33)	12	20
G. Private transfer wealth	(3)	(7)	(10)	(7)	(25)	(64)	(123)	(104)	(7)	74	92
H. Total transfer wealth (F + G)	**54**	**83**	**111**	**115**	**27**	**(81)**	**(175)**	**(164)**	**(40)**	**86**	**112**
I. Private generational account (E − H)	**49**	**102**	**189**	**262**	**241**	**184**	**126**	**98**	**96**	**82**	**74**
J. Non-housing wealth*	117	118	191	288	215	79	4	(3)	(0)	0	0
K. Housing wealth*	160	160	164	178	163	132	79	15	0	0	0
L. Savings gap (I − J − K)	**(228)**	**(176)**	**(167)**	**(204)**	**(136)**	**(27)**	**42**	**86**	**96**	**82**	**74**
Panel B: public generational account (equals public transfer wealth above)											
M. PV(public consumption)	45	76	109	132	141	141	137	135	148	160	154
N. PV(public cash transfers received)	36	67	101	116	115	123	133	134	116	85	76
O. PV(taxes paid)	25	52	88	126	203	281	321	328	296	233	209
P. Public generational account (M + N − O = F)	**56**	**90**	**122**	**122**	**52**	**(17)**	**(52)**	**(59)**	**(33)**	**12**	**20**

Notes: Public consumption includes health, education, unallocated expenditure (e.g., defence and police) and social care. Private consumption is all other consumption. Human capital is defined as the expected discounted present value of wages. Half of the value of student loans issued are treated as public consumption at the time of issue, and half as private consumption, reflecting likely repayment behaviour. Public transfers received include the value of in-kind transfers (these comprise public consumption) and cash transfers, derived from a combination of the LCFS and administrative data. Public transfers made are taxes and user charges (e.g., the BBC license fee) paid by the household sector to the public sector. Private transfers include inter-household and intra-household transfers, calculated as per the national transfer accounts (Lee and Mason, 2011) methodology. Private transfers to the RoW are allocated by age using the same profile as domestic private transfers. The per capita present values shown in the table (other than net worth) are calculated using profiles derived from the Living Cost and Food Survey (and its antecedents), balanced to macro-economic aggregates for 2015 obtained from the national accounts and projected using an APC model described in the text. The methodology is described in the text and Online Appendix B, and detailed results are available in Online Appendix C. Population projections are the principal projection of the ONS (2016). Net worth is derived from the Wealth and Asset Survey, and includes net financial wealth (including defined benefit and defined contribution occupational pensions), housing wealth and the value of household contents (excluding automobiles). * Wealth data are sparse for the top two age groups, leading to increased uncertainty in wealth estimates at these ages.

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Line L shows the per capita savings gap, the difference between the private GA and the amount of wealth actually held by each cohort representative. For those over the age of forty, the savings gap is negative, and for those older than sixty, it is very large. Because these amounts will be passed as capital transfers to the young, these results show that inter-generational capital transfers are highly significant. Those younger than fortyhave not accumulated enough wealth to meet their private GA, and have positive savings gaps. Yet this does not imply that their consumption plans are unsustainable, just that they will need to rely on capital transfers from the older generations if their consumption plans are to be realised. These results are particularly striking in the context of Gokhale *et al.* (1996), who ignored capital transfers between generations (but did discuss the implications of this decision).

Panel B of Table 1 shows the public generational accounts that provide more information about the composition of public transfer wealth in line E of panel A. These are similar to those published in Carderelli *et al.* (2000) but abridged, updated to 2015 and oppositely signed. The accounts show a large positive transfer for older generations, a negative transfer for working age living generations and positive again for younger and the unborn.

The position of the unborn requires some comment. Their per capita life-cycle demand for assets is highly positive, indicating that their own labour income is not sufficient to finance their lifetime consumption plans. To some extent, this is unsurprising: children rely on transfers from their parents to finance their consumption in the first quarter of their lives. Yet Table 1 shows that on average, only around half of their life-cycle demand for wealth is financed by private transfer wealth. Roughly, another 10% is financed by public transfer wealth, with the remainder comprising the savings gap. The positive public transfer wealth of the unborn is suggestive of long-run sustainability problems in the public sector, although the age distribution of the population, and the current public-sector net worth, both only visible in aggregate accounts, will matter. Likewise, it does not follow from the positive savings gap of the young and the unborn that private-sector consumption plans are unsustainable; the positive savings gap just shows that capital transfers from the old will need to be substantial for private-sector consumption patterns to be sustainable. Again, only aggregate accounts will indicate whether or not actual capital transfers will be sufficient to cover these shortfalls. We therefore move from per capita generational accounts to the aggregate GWA, presented in Table 2.

The left-hand part of Table 2, panel A, shows the resources and the uses to which those resources are put, presented in the form of a comprehensive balance sheet for each generation. ‘Resources’ include human capital, net worth, the present value of public and private transfers received and any positive savings gap. ‘Uses’ are the present value of public and private consumption, the present value of transfers made and any negative savings gap. Each item is obtained by multiplying the corresponding per capita item in Table 1 with the appropriate population at each age, shown in the first row of the table.

The broad patterns in panel A of Table 2 are unsurprising given the population structure of the UK and the per capita patterns shown in Table 1. However, (6) show how these aggregate results can be used to calculate the size of flows between the generations in the three transfer systems we examine. As an illustration, the next column (shown in italics because the figures in it are included in panel A to the left) breaks out transfers between the living and the unborn. In PV terms, the unborn receive net £2,326 billion (line C) in private transfers from those currently living, which largely flows from living parents to their unborn children. On the other hand, the unborn transfer net £921 billion to the living through the public transfer system (line M). This reflects the net reliance of living generations on future taxes paid by those not yet born. In current

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Table 2. *Generational Wealth Accounts for the UK, 2015 (2015 GBP billion).*

	Panel A Year of birth												Panel B Calculation of fiscal and savings gaps				TOTAL
	before 1926	1926–35	1936–45	1946–55	1956–65	1966–75	1976–85	1986–95	1996–2005	2006–15	After 2015	Of which: transfers between living and unborn	Public sector net worth	Public transfers to RoW	Net public transfers deficit	Net capital transfers deficit	
Age in 2015	90+	80–89	70–79	60–69	50–59	40–49	30–39	20–29	10–19	0–9	Unborn						
Population (million)	0.56	2.55	4.89	7.12	8.52	8.93	8.46	8.74	7.37	7.98							65.11
A. Human capital	0	0	12	280	1,962	3,964	5,152	5,826	4,298	3,369	8,414						33,276
B. PV(public transfers received)	45	363	1,026	1,768	2,178	2,356	2,280	2,348	1,944	1,961	5,240				(1,387)		20,121
C. PV(private transfers received)	7	64	253	631	989	1,164	1,082	1,272	1,514	1,848	5,238	2,326					14,063
D. Non-housing wealth	65	301	935	2,052	1,832	706	37	(24)	(0)	0	0		(1,986)				3,916
E. Housing wealth	89	409	803	1,267	1,386	1,178	672	130	0	0	0						5,934
F. Savings gap (+)	0	0	0	0	0	0	353	753	706	653	1,700	1,783				84	4,249
G. Aggregate savings gap																(84)	(84)
H. Fiscal gap													1,986	545	1,387		3,918
I. TOTAL RESOURCES	**206**	**1,137**	**3,027**	**5,997**	**8,347**	**9,367**	**9,577**	**10,304**	**8,463**	**7,831**	**20,593**		0	545	0	0	85,395
J. PV(public consumption)	25	193	534	942	1,198	1,258	1,157	1,176	1,091	1,280	3,515						12,370
K. PV(private non-housing consumption)	18	166	604	1,371	2,151	2,620	2,577	2,965	2,687	2,570	6,898						24,627
L. PV(private housing consumption)	14	115	341	648	899	1,004	999	1,115	930	862	2,263						9,190
M. PV(public transfers made dom)	14	132	431	898	1,733	2,510	2,718	2,864	2,185	1,862	4,774	921					20,121
N. PV(private transfers made dom)	8	81	298	673	1,187	1,712	2,104	2,160	1,546	1,230	3,063						14,063
O. PV(transfers made to RoW)	0	2	5	11	17	20	22	25	23	26	79			545			774
P. Savings gap (–)	127	449	814	1,454	1,162	244	0	0	0	0	0						4,249
Q. TOTAL USES	206	1,137	3,027	5,997	8,347	9,367	9,577	10,304	8,463	7,831	20,593			545			85,395
For information																	
R. Life-cycle dem. for assets (J + K + L − A)	57	474	1,467	2,681	2,286	918	(419)	(570)	411	1,344	4,262						
S. Total transfer wealth (B + C − M − N − O)	30	212	544	816	230	(722)	(1,481)	(1,428)	(296)	690	2,562						
T. Private generational accounts (R − S)	27	262	923	1,864	2,056	1,640	1,062	859	706	653	1,700						
U. Wealth (D + E)	154	710	1,737	3,318	3,218	1,884	709	106	(0)	0	0						
V. Savings gap (T − U = F − P)	(127)	(449)	(814)	(1,454)	(1,162)	(244)	353	753	706	653	1,700						

Notes: Public-sector net worth is obtained from the Whole of Government Accounts, and includes the unfunded portion of occupational pension promises where the public sector is the employer, and the value of assets owned by the public sector. Private-sector net worth is obtained from the Wealth and Asset Survey and balanced to the implied survey total. Transfers to the RoW, line M, consist of both private and public transfers to the RoW; private transfers are allocated to generations and public transfers are capitalised, assuming they grow in perpetually at rate $g = 1.5\%$ p.a. See the notes to Table 1 for details about assumptions underlying the calculation of present values.

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transfer terms, the unborn are therefore net recipients from the living (to the amount of £2,326 billion – £921 billion = £1,405 billion), a finding consistent with the United States (Lee *et al.*, 2017). But in addition to these current transfers, because living generations have an aggregate savings gap of negative £1,783 billion (a surplus, line F), this implies a positive capital transfer from the living to the unborn of this amount. Similar calculations can be carried out between any two sets of generations using (6).

Panel B of Table 2 uses the aggregate flows in panel A to construct the fiscal gap and the aggregate savings gap from their various components. The first column shifts the public-sector net worth from household non-housing wealth (where it is held as an asset) to the fiscal gap.[40] The second records the present value of net public transfers made to the rest of the world, while the third moves the difference between the aggregate present value of public transfers made and received to the fiscal gap. The final column does the same for the savings gaps of each generation. These adjustments ensure that the total housing and non-housing wealth in the far-right column balances to national net worth; the total private (public) transfers made to residents equals the total private- (public-)sector transfers received and the total positive savings gap (shown as resources) equals the total negative savings gap (shown as uses), so nets out. Consistent with (5), the aggregate total of human capital (line A), national net worth (lines D and E) and the savings and fiscal gaps (lines G and H) therefore equals the present value of public (line J) and private (line K) consumption and public and private transfers made to the rest of the world (line O), and the accounts balance, as can be seen by comparing the total all-generation resources and uses of £85,395 billion.

The final section of Table 2, included for information, shows the aggregate life-cycle demand for assets, total transfer wealth, private generational accounts net worth and savings gap for each generation.

3.1. *Sustainability*

In 2015, the UK had a negative SG of £84 billion (or 4% of GDP; 0.2% of the present value of consumption), indicating that private-sector consumption plans are slightly in surplus, despite the large per capita savings gap of the unborn. Older generations have more than sufficient resources to support their own consumption and can leave £4,249 billion (the sum of negative savings gaps, row P) in bequests to younger generations. This flow is sufficient to cover the positive savings gaps of the living generations, as well as the unborn (the sum of row F), leaving an overall surplus of £84 billion.

Our estimate of the future value of bequests (the sum of negative savings gaps, row N, £4,249 billion) compares well with our estimate of the present value of bequest flows from HRMC data, and our estimate of inter vivos capital transfers. In 2015, HMRC[41] estimated that the total value of all probated estates as £79 billion. Atkinson (2018) suggested this to be an undercount,[42] and

[40] We ignore foreign holdings of UK government debt because these are roughly offset by domestic holdings of foreign debt in household net worth.

[41] ‘Inheritance tax statistics’, Table 12.4, ONS (2016).

[42] This is an underestimate of the total value of estates bequeathed, because estates in joint names (that is, bequests of jointly owned property between spouses under UK law) or below £5,000 do not require probate. Karagiannaki (2015) estimated that only around 50% of estates by number go through probate. Atkinson (2018) observed that most of these non-recorded transfers are either ‘sideways transfers’ (to spouses) and so can be ignored when the focus is on transfer down the generations, or of negligible value and likely to amount in total to less than 2% of the recorded transfers. However, Atkinson did make a significant adjustment for the exclusion (e.g., trusts) and undervaluation (particularly houses) of some assets.

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recommended adding an additional 25% to the recorded total for years after 1995, so for 2015, £99 billion is a better estimate of the annual flow. In addition, from the fifth wave of the WAS survey[43] we estimate inter vivos capital transfers in 2015 at £11 billion,[44] leading to a total flow of £110 billion in 2015. Working with the above estimates, the present value of an annuity of £110 billion (£99 billion bequests plus £11 billion inter vivos transfers) growing at 1.78%[45] with a discount rate of 5% is £3,416 billion, close to the total savings gap of the older generations of £4,249 billion.

On the other hand, the FG in 2015 was positive £3,918 billion (or 207% of GDP; 8.5% of the present value of consumption), comprising the public-sector net liability of nearly £1,986 billion, the present value of future deficits in public-sector consumption plans of just over £1,387 billion and the capitalisation of public future transfers to the rest of the world of £545 billion. To close this gap would require the sum of public and private consumption to be cut by 8.5%. This figure is not directly comparable to estimates by both the European Commission (2016) and Office for Budget Responsibility (2017) of the sustainability of the UK's public finances: their projections incorporate some proposed budget tightening as well as different underlying economic assumptions.[46] However, the OBR estimates a permanent tightening of 7% of GDP, whereas the European Community estimates that 5.7% of GDP[47] is necessary to close the fiscal gap.

The nominal UK CG in 2015, the sum of the SG and the FG, was therefore £3,834 billion (199% of GDP). This is equivalent to a cut of 8.3% of the PV of all future public and private consumption. UK aggregate consumption plans were therefore unsustainable in 2015.

3.2. *The Offsetting Nature of the Public and Private Sectors*

We now turn to an examination of how these sustainability measures changed over the period of the financial crisis by estimating GWA for each year from 2005–15. Figure 2 plots the SG, FG and CG (uprated to 2015 in line with productivity and prices) in each of these years. The productivity-adjusted FG and SG are strongly negatively correlated (−0.78 in levels; −0.49 in differences); this is similar to the correlation de Mello *et al.* (2004) found between private- and public-sector savings rates for any of the twenty-one countries.[48] However, of more interest is

[43] The survey asks all households to estimate the total value of gifts or loans over £500 received in the last two years. This amounted to a total of £22 billion or £11 billion per year. In these questions, responders tend to recall more recent transfers and further the question ignores gifts below £500.

[44] Again, this may be a significant underestimate; both Wolff (1999) and Karagiannaki (2015) argued that inter vivos transfers are possibly more prone to underestimation than bequests. Wolff (1999) even suggested that the total sum transferred inter vivos could be as large as the sum transferred through bequests. Both Karagiannaki (2015) and Atkinson (2018) suggested inter vivos gifts add an extra 10% to transferred wealth; amounting to roughly £10 billion in 2015.

[45] Productivity growth of 1.5% plus population growth of 0.28%.

[46] OBR assumes a productivity growth rate of 2%, a long-run real interest rate of 2.6%. We discussed in Subsection 2.3 our reasons for discounting the future tax and public expenditure streams at the cost of capital not the risk-free rate. However, we show in Table 2 that the necessary percentage change in public consumption to close the gap is not particularly sensitive to the choice of interest rate. Another difference is the OBR assumes that real public health expenditure grows faster than productivity growth rate due to health cost pressures over the medium to long term. We do not.

[47] The closest equivalent figure in Office for Budget Responsibility (2017, p.84, paragraph 4.9) is denoted the Intertemporal Budget Gap. In European Commission (2016, p.303), the closest equivalent figure is the S2 indicator under the historical Structural Primary Balance (SPB) scenario.

[48] Though the correlations are obviously not directly comparable—our estimates take into account changes in net worth as well as changes in future government liabilities—they found a correlation of −0.63 for the UK over the period 1970–2002 and an average −0.53 for all twenty-one OECD countries.

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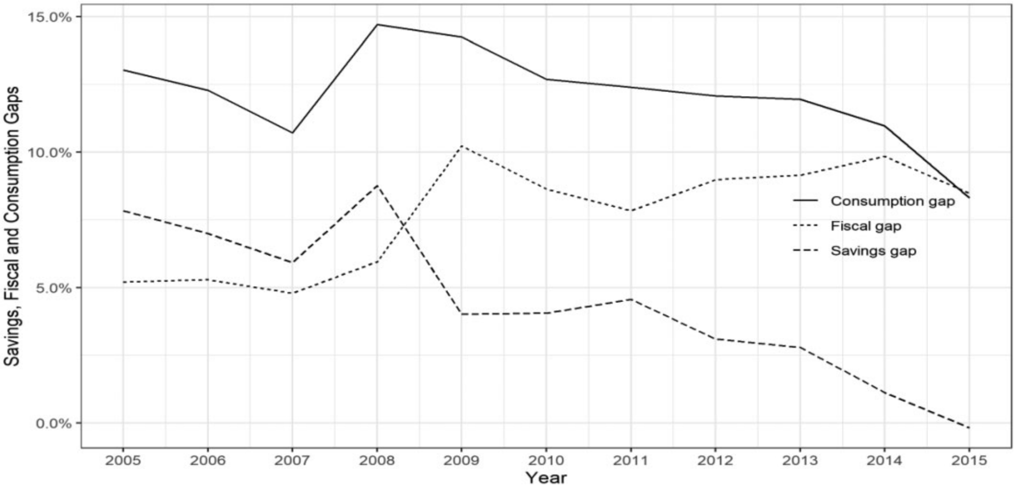

Fig. 2. *Savings, Fiscal and Consumption Gaps 2005–15.*
Notes: For each year 2005–15, the GWA are calculated following the APC approach used in our base case, described in the text. The chart plots the savings, fiscal and consumption indicators for each year normalised by the present value of total consumption in that year. Note that the figure is virtually identical (after appropriate changes in scale on the vertical axis) if either the gaps are plotted on the productivity-adjusted basis or normalised by trend GDP.

the CG over this period. This remained relatively stable, rising slightly between 2007 and 2008 before falling back to a lower level in 2015, lower than the prior minimum it achieved in 2007. As shown in Figure 1, over this period, yearly national savings[49] in the UK economy fell by 3 percentage points of GDP. However, the CG suggests that the impact of the fall in savings rates was offset by increases in net worth and human capital.

To illustrate the components of these changes in more detail, Table 3 shows changes in the per capita GWA between 2005 and 2015, in 2015 GBP thousands. The 2005 numbers are adjusted for both price rises and productivity increases. Savings gaps decreased at all ages, indicating an improvement in sustainability, but for different reasons. For those generations older than around sixty, the most striking change is the increase in the value of per capita housing and other wealth. This is a consequence of both higher private savings rates over the period, shown in Figure 1, and capital appreciation of dwellings and to a far lesser extent financial assets. The present value of their private consumption also increased over this period but by proportionally less. Those aged over sixty in 2015 held on average[50] £101,000 more in assets than the same age groups in 2005 once we have adjusted for productivity gains. The PV of their private consumption increased by £16,000 on average, which is 16% of the asset gain. Similar figures for those aged over seventy in 2015 are an increase of £74,000 in assets and of £18,000 (24% of assets) in private consumption. We therefore estimate that roughly 80% of the increase in assets of those older than sixty-five will be passed on as a capital transfer to younger generations. Increases in the present value of housing consumption only account for around 15% of the increase in housing wealth.

[49] Savings rates shown in the figure do not include capital appreciation, which explains most of the increase in private-sector net worth.

[50] We use the population in 2015 to average the per capita numbers in Table 3; using the population in 2005 gives identical estimates.

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Table 3. *Productivity-adjusted Changes in Public and Private Per Capita Generational Accounts, 2005–15 (2015 GBP thousands).*

	Year of birth										
Age in 2015	Before 1926 90+	1926–35 80–89	1936–45 70–79	1946–55 60–69	1956–65 50–59	1966–75 40–49	1976–85 30–39	1986–95 20–29	1996–2005 10–19	2006–15 0–9	After 2015 Unborn
Panel A: private generational account and savings gap											
A. PV(public consumption)	(4)	5	12	11	8	6	3	(3)	(12)	(31)	(30)
B. PV(private non-housing consumption)	(0)	9	18	10	(5)	(7)	(28)	(19)	(12)	(14)	(7)
C. PV(private housing consumption)	2	3	5	4	2	3	2	(1)	(1)	(1)	(1)
D. Human capital	0	0	2	7	41	22	21	(37)	(21)	(2)	8
E. Life-cycle demand for assets (A + B + C − D)	**(2)**	**17**	**33**	**18**	**(37)**	**(21)**	**(44)**	**13**	**(4)**	**(44)**	**(46)**
F. Public transfer wealth	2	4	12	9	3	8	13	24	(4)	(24)	(25)
G. Private transfer wealth	(3)	(6)	(1)	1	(12)	10	(14)	16	21	(2)	(3)
H. Total transfer wealth (F + G)	**(2)**	**(2)**	**11**	**9**	**(9)**	**18**	**(1)**	**40**	**17**	**(26)**	**(28)**
I. Private generational account (E − H)	**(1)**	**19**	**23**	**9**	**(28)**	**(39)**	**(44)**	**(27)**	**(21)**	**(17)**	**(18)**
J. Non-housing wealth*	50	43	53	96	38	9	8	7	0	0	0
K. Housing wealth*	47	40	13	34	6	(6)	(17)	(13)	(0)	0	0
L. Savings gap (I − J − K)	**(98)**	**(65)**	**(44)**	**(122)**	**(72)**	**(42)**	**(35)**	**(22)**	**(21)**	**(17)**	**(18)**
Panel B: public generational account (equals public transfer wealth above)											
M. PV(public consumption)	(4)	5	12	11	8	6	3	(3)	(12)	(31)	(30)
N. PV(public cash transfers received)	5	10	9	(4)	7	15	7	2	(1)	2	4
O. PV(taxes paid)	(1)	11	9	(1)	12	13	(3)	(26)	(10)	(4)	(1)
P. Public generational account (K + L − M = E)	**2**	**4**	**12**	**9**	**3**	**8**	**13**	**24**	**(4)**	**(24)**	**(25)**

Notes: The table shows the changes in the per capita public and private generational accounts between 2005 and 2015, where the 2005 accounts have been uprated for changes in prices and productivity using the wage index described in footnote 27. A positive number indicates that the 2015 quantity is larger than the productivity- and price-adjusted 2005 quantity. * Wealth data are sparse for the top two age groups, leading to increased uncertainty in wealth estimates at these ages.

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For those between thirty and sixty, the causes of the fall in the savings gap was different. Although net worth increased for this group (by £13,000), the increase in human capital was £28,000, largely the result of later retirement. Private consumption fell by £11,000. For those younger than thirty, sustainability increased largely because of reductions in the present value of consumption (£15,000 for public; £20,000 for private), offset by a reduction of £21,000 in human capital for these generations (partly due the postponement of entry into the labour force and partly because of lower wages).

3.3. *The Role of Housing*

Housing is a very important part of UK household portfolios, and house prices play an outsize role in public discussion of inter-generational issues. To allow us to examine the role played by housing in more detail, we separated housing and non-housing-related consumption and wealth in our analysis. Though the capital appreciation of dwellings might improve the financial position of one generation relative to another, one can show, albeit under strong economic assumptions,[51] that price changes alone will have no effect on sustainability. Between 2005 and 2015, aggregate gross housing wealth increased in 2015 productivity-adjusted prices from £5,248 trillion to £5,934 trillion (Table 2, line E).[52] Yet, over the same period, we show that the present value of all future consumption of housing services also increased (again in 2015 productivity-adjusted prices), from £8,688 trillion in 2005 to £9,190 trillion in 2015 (line L). In aggregate, the increase in the value of houses was thus largely offset by the increase in the present value of housing consumption, leaving sustainability little changed. Our reported improvement in the aggregate sustainability position is therefore mainly the consequence of the increase in total human capital (due predominantly to estimated later retirement), reductions in consumption (predominantly by the young) and increased non-housing wealth accumulation due to higher private-sector savings over this period.

However, Table 3 shows that the change in house prices did indeed redistribute resources between the generations from the young to the old: the value of per capita gross housing wealth increased faster than prices and productivity for the old, but relatively slower for the young (line K), while the present value of housing services increased relative to prices and productivity much more evenly across the generations (line E). However, this has no major impact on aggregate sustainability precisely because capital transfers offset most of this effect. We stress again that this result holds only at the aggregate cohort level, but says nothing about the likely distributional effects of house price changes within cohorts, a point to which we return in the conclusion.

In Online Appendix D, we report robustness checks and show that our conclusions are broadly unchanged regardless of the approach we use to project profiles, and the precise values of the financial and demographic assumptions we use.

4. Conclusion

In this paper, we provided an integrated framework for studying inter-generational transfers by developing and calculating GWA. The GWA employ the framework of the NTA of Lee and Mason

[51] Disney *et al.* (2010) discussed these assumptions and gave a list of factors that could give rise to aggregate real effects.

[52] Our wealth aggregates are obtained from the WAS, and are close to the change in the estimates of the value of land and dwellings in the UK National Balance Sheet (ONS series E46Y and E44R), from (productivity and price adjusted) £5.6 trillion in 2005 to £6.4 trillion in 2015.

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(2014) to extend the public-sector GA of Auerbach *et al.* (1991) to the whole economy. GWA allow us to measure how much current generations are likely to leave future generations, not only through the public sector but also through the private sector, and there whether as current or capital transfers (bequests and inter vivos gifts). We then showed how GWA can be used to assess the sustainability of the consumption plans of current and future generations. Unlike previous measures, GWA-derived measures of sustainability take account of population ageing, public- and private-sector assets and liabilities, and current and capital transfers within the public and private sectors.

We calculated GWA for the UK over the period 2005–15 and used the results to measure how inter-generational transfers and consumption sustainability changed in response to the financial crisis. The GWA confirmed both the worsening in public-sector finances, and the increase in private wealth. However, they revealed that because the elderly will likely consume only around a fifth of the increase in their private wealth, the balance will likely be transferred to the young through future capital transfers, largely offsetting, in aggregate, the dramatic worsening of the public finances. We found that despite the crisis, the sustainability of aggregate consumption plans in the UK actually improved between 2005 and 2015. This was due to several factors that include increased saving rates after the financial crisis, extensions in working life and reduced consumption of the young. This was offset by an increase in consumption of the old, but an increase that was significantly less than their increase in wealth holdings.

These results do suggest tensions in the inter-generational contract. Public-sector fiscal plans are unsustainable and are likely to leave increasing levels of debt to future generations unless there is a significant shift in policy. Furthermore, we find evidence that younger generations are indeed consuming less than their predecessors did at similar ages. Our results suggest that the generation born in 1990 is consuming roughly 7.5% less than the generation born in 1970 did at the same age, after adjusting for productivity increases, in addition to reductions associated with the postponement of working life. Projected private-sector surpluses—the consequence of higher asset accumulation, longer working lives and lower consumption of the younger cohorts—are not sufficient to offset public-sector unsustainability. This suggests that not only will there need to be a rebalancing between the public and the private sectors, but also further reductions in overall consumption.

Our finding that private assets play a crucial role in offsetting the aggregate effects of fiscal unsustainability raises many important future research questions, of which we mention just two. Our analysis investigates whether there are sufficient resources at the aggregate cohort level to sustain future consumption patterns. But policies aimed at rebalancing between the private and public sectors will need to consider the distribution of these resources at both the intra- and inter-generational levels. It seems likely to us that some members of each cohort—members of dynasties with large asset holdings—will consume substantially less than their sustainable level, while others—possibly those more reliant on public-sector transfers—will consume substantially more than theirs. Population ageing may only exacerbate these differences as private wealth rises and population ageing places the public sector under increasing strain. The next stage of our work will therefore examine inter-generational transfers in the context of both intra- and inter-generational inequalities.

Secondly, many researchers believe that population ageing may lead to capital deepening[53] that, by raising the labour productivity of subsequent generations, could prolong the beneficial

[53] Others disagree, pointing out the possibility of secular stagnation. See Lee (2016) for a discussion of these points.

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effects on economic growth of the middle stages of the demographic transition.[54] Our current paper highlights the issue that rising public-sector debt could crowd out capital formation and hinder capital deepening, increasing the burden of ageing. This paper suggests that research into the capital deepening associated with population ageing must consider not only private current and capital transfers, but also any potential offsetting effects between the public and private sectors..

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Additional Supporting Information may be found in the online version of this article:

Online Appendix
Replication Package

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[54] Called the second demographic dividend. See Mason and Lee (2006).

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