THE SUSTAINABILITY OF SCOTTISH PUBLIC FINANCES: A GENERATIONAL ACCOUNTING APPROACH

Katerina Lisenkova[a,b,c]

Miguel Sanchez-Martinez[a]

James Sefton[d]

a National Institute of Economic and Social Research

b Centre on Constitutional Change

c Centre for Macroeconomics

d Imperial College London

NIESR Discussion Paper No. 456

Date: 7 December 2015

National Institute of Economic and Social Research

About the National Institute of Economic and Social Research

The National Institute of Economic and Social Research is Britain's longest established independent research institute, founded in 1938. The vision of our founders was to carry out research to improve understanding of the economic and social forces that affect people's lives, and the ways in which policy can bring about change. Seventy-five years later, this remains central to NIESR's ethos. We continue to apply our expertise in both quantitative and qualitative methods and our understanding of economic and social issues to current debates and to influence policy. The Institute is independent of all party political interests.

National Institute of Economic and Social Research
2 Dean Trench St
London SW1P 3HE
T: +44 (0)20 7222 7665
E: enquiries@niesr.ac.uk
niesr.ac.uk
Registered charity no. 306083

This paper was first published in December 2015

The sustainability of Scottish public finances: a Generational Accounting approach

Katerina Lisenkova, Miguel Sanchez-Martinez and James Sefton

Abstract

This paper analyses the long-term sustainability and intergenerational equity of the Scottish public finances by employing a generational accounting model. This represents a novel approach to analysing these issues in the case of Scotland, while having the advantage of capturing policy-relevant intergenerational aspects. We find that, under the baseline scenario, assuming that Scotland has "full fiscal autonomy", large intertemporal and intergenerational fiscal gaps open up. The three main reasons behind this result are: declining North Sea revenues, a budget deficit at the beginning of the simulation period and a widening gap over time primarily due to population ageing. The model suggests that both the intertemporal fiscal and generational imbalances can be addressed via a permanent increase in taxes equivalent to about 8.5 per cent of Scottish GDP, levied on both living and future generations.

Acknowledgements

Financial support from the Economic and Social Research Council under the grant "Centre on Constitutional Change" is gratefully acknowledged.

Contact details

Katerina Lisenkova (k.lisenkova@niesr.ac.uk), National Institute of Economic and Social Research, 2 Dean Trench Street, London SW1P 3HE

1. Introduction

Generational accounting is a method originally developed by Auerbach et al. (1991) and Kotlikoff (1992) which is aimed at analysing and evaluating the effect of current fiscal arrangements on both public sector solvency and the redistribution of fiscal burden between generations. In particular, the questions that this approach seeks to answer are: how large a fiscal burden does current policy imply for future generations? What kind of policy changes are required to ensure long run sustainability of the public finances? What policies would generate intergenerational balance[1] (i.e. a situation where future generations face the same fiscal burden as current generations)?

By permitting the investigation of not only purely intertemporal but also intergenerational fiscal issues, this modelling approach represents a complement to other models used in the related literature. At a time when the old-age dependency ratio is expected to increase rapidly and where there is rising preoccupation on the state of the world that future generations will inherit, the investigation of intergenerational issues lies at the forefront of the policy debate on the sustainability of the public finances.

A generational account (GA) is defined as the expected present value of the taxes paid minus the benefits and public services received by individuals of different cohorts over their remaining lifetimes, taking current and projected future policy as given. The key idea behind generational accounting is that the government bills (i.e., the present value of the government's current and future expenditure plus its net debt) that are not fully covered by current generations, need to be paid for by future generations for fiscal intertemporal balance to hold. The extent of this intertemporal shift of the fiscal burden will determine how generationally unequal the current fiscal situation is.

This paper represents the first attempt at producing a set of GAs for Scotland and provides an analysis of the different fiscal adjustments that would be needed to achieve both intertemporal as well as intergenerational balance. It also explores a number of alternative scenarios. This work builds on Cardarelli, Sefton and Kotlikoff (2000) and McCarthy, Sefton

[1] The idea of intergenerational balance or equity attracted a lot of attention recently. There is a growing perception that younger and future generations have been economically disadvantaged. Here we investigate only one aspect of intergenerational equity – its fiscal component. In the context of this paper, the policy would be described as intergenerationally fair if future generations are required to pay the same share of their lifetime earnings in net taxes.

and Weale (2011) who developed GAs for the UK. This paper updates and extends the analysis of the Scottish fiscal sustainability presented in Amior et al (2013). We use the most recent available fiscal information and forecasts, which suggest that the long-term outlook for Scotland has worsened.

This set of GAs is built using three types of data: 1) population projections from the Office for National Statistics (ONS); 2) publicly available projections for the main fiscal items (OBR, 2015; DWP, 2015); 3) age profiles of public revenues/transfers. The latter are estimated using cross-sectional survey data as well as administrative data for Scotland.

In our baseline scenario, which assumes that Scotland has "full fiscal autonomy"[2], the results show that future Scottish generations bear a higher tax burden than their predecessors, after adjusting for productivity growth. Specifically, for the intertemporal budget constraint to be satisfied, future generations need to make a present value net lifetime contribution (taxes less benefits and public services received) over 2 times larger than that made by individuals born in 2013 (the base year of our analysis). Likewise, our results imply that, in order to achieve intergenerational equity, either total tax revenues have to permanently rise by an amount equal to about 8.2 per cent of GDP, thereby making current generations increase their contributions, or government spending has to fall to reduce the fiscal pressure on future generations. Even if intergenerational equity is not a concern, the current path for the public finances is unsustainable, as it implies that the government holds a negative intertemporal net fiscal position in the base year, thereby violating the intertemporal budget constraint. Restoring the intertemporal fiscal balance requires permanently increasing overall tax revenue by about 8.5 per cent of GDP.

We compare a baseline scenario with a number of counterfactual simulations to investigate major factors contributing to the intertemporal and intergenerational gaps. We compare the situation in Scotland with the UK as a whole and also investigate the intertemporal and intergenerational balances under current devolution plans.

The paper is organised as follows. In section 2 a brief introduction to the method of generational accounting is provided. Section 3 describes the assumptions and data sources

[2] This term is often used in discussions of Scotland's devolution process. We use it to describe a situation where the Scottish Government has autonomy over all fiscal revenue and spending items. However, such definition excludes other aspects of full fiscal autonomy, such as deposit insurance or financial sector bail-out schemes and natural disaster insurance. For this reason we put this term in quotation marks.

used. In section 4 the results for the GAs of Scotland and the UK are presented and various scenarios are discussed. Finally, section 5 contains a summary of main messages and provides some concluding remarks.

2. The Generational Accounting approach[3]

The generational accounting methodology revolves around the concept of the intertemporal budget constraint, according to which the present value of current and future government spending must be funded out of three possible sources: the present value of net contributions (i.e., taxes minus transfers and public services) made by presently alive generations, the present value of net contributions made by future generations and current net public debt (i.e., the value of the stock of debt minus the value of the government's assets).

One of the main advantages of this approach is that it explicitly captures the effects of changes in both total population and its age distribution across time and that it underscores potential disparities between generations. In relation to the last point, all else equal, a reduction in the net taxes paid by presently alive generations must be accompanied by a corresponding increase in net taxes paid by future generations.

Formally, the intertemporal budget constraint reads:

$$\sum_{s=0}^{M} N_{t,t-s}\, P_{t,t-s} + \sum_{s=1}^{\infty} N_{t,t+s}\, P_{t+s,t+s}(1+r)^{-s} = \sum_{s=0}^{\infty} G_{t+s}\,(1+r)^{-s} + D_t \qquad (1)$$

where $N_{t,k}$ stands for the present value of the average remaining lifetime net contributions, i.e., the GA in period *t* of the generation born in year k[4]. $P_{t,k}$ is the size of the generation born in year *k* at time *t* and *r* stands for the government's real, before-tax, discount rate. The first term on the left-hand side of equation (1) represents the sum of the GAs (i.e. aggregate net tax contributions) of generations alive at time *t* weighted by the size of those generations. It starts with the generation born at time *t,* and goes all the way to the generation born *M* years ago (where *M* is the maximum age, assumed to be 101 years in our case). The second term on the left-hand side reflects the weighted sum of GAs of the yet unborn generations, expressed in time-*t* real terms. The first expression on the right-hand

[3] This section draws heavily on Cardarelli, Kotlikoff and Sefton (2000) and McCarthy, Sefton and Weale (2011).
[4] For example, $N_{t,t}$ represents the time-*t* GA of those born at time *t*; $N_{t,t-65}$ is the GA of those who are 65-years-old at time *t*, and $N_{t,t+30}$ is the GA of those who will be born 30 years after base year *t.*

side is the time-t value of the stream of net government purchases which are not allocated to individuals, G_t[5]. The remaining term, D_t, denotes the level of net public debt.

The formal expression for the GA in period t of the cohort of individuals born in period k is:

$$N_{t,k} = \sum_{s=\max(t,k)}^{k+M} T_{s,k} \left(\frac{P_{s,k}}{P_{k,k}}\right)(1+r)^{-(s-t)} \quad (2)$$

where $T_{s,k}$ stands for the projected average net tax payment made in year s by a member of the generation born in year k, and $\frac{P_{s,k}}{P_{t,k}}$ indicates the proportion of members of cohort k alive at time t who will also be alive at time s to pay taxes.

Comparing the GA of current newborns with a hypothetical, constant GA for future generations provides an idea of the extent of generational imbalance. Let $\bar{N}$ denote this theoretical GA for future generations. We can then write:

$$\sum_{s=0}^{M} N_{t,t-s} P_{t,t-s} + \sum_{s=1}^{\infty} \bar{N}(1+g)^s P_{t+s,t+s}(1+r)^{-s} = \sum_{s=0}^{\infty} G_{t+s}(1+r)^{-s} + D_t \quad (3)$$

where $\bar{N}$ represents the constant GA of future generations which would be compatible with the satisfaction of the intertemporal budget constraint. We assume that the net contributions of future generations increase at the real rate of productivity growth, g. Assuming that real earnings increase at the same rate, this means that future generations pay the same share of their lifetime earnings in net taxes.

Comparing the GA of current newborns with this constant GA for future generations provides an idea of the extent of generational imbalance. If $\bar{N}$ equals $N_{t,t}$ (the GA of time-t newborns), there is intergenerational balance. On the contrary, whenever $\bar{N} \neq N_{t,t}$, an intergenerational imbalance exists: if $\bar{N} > N_{t,t}$ ($\bar{N} < N_{t,t}$), then future generations face a larger (smaller) growth-adjusted lifetime net tax burden than current newborns. In the situation where $\bar{N} > N_{t,t}$, from Equation (3) we conclude that current fiscal policy is both generationally imbalanced and unsustainable, in the sense that if future generations were to contribute as much as current newborns, these contributions would be insufficient to cover government expenses.

[5] Unallocated receipts and purchases include those items that cannot reasonably be allocated to individuals. Examples of unallocated government spending include defence and environmental protection. An example of an unallocated receipt is North Sea revenues.

To distinguish between the financial sustainability of fiscal policies, on one hand, and the degree of intergenerational equity, on the other, let us formally define the concept of the intergenerational balance gap (IGG). This gap, expressed as a percentage of GDP, provides a measure of the extent of fiscal adjustment that would be needed to achieve both intergenerational and intertemporal fiscal balance:

$$IGG = \frac{\sum_{s=0}^{\infty} G_{t+s}(1+r)^{-s} + D_t - \sum_{s=0}^{M} N_{t,t-s}P_{t,t-s} - \sum_{s=1}^{\infty} N_{t,t}(1+g)^{s}P_{t+s,t+s}(1+r)^{-s}}{GDP} \quad (4)$$

Equation (4) gives the difference between the government's bills, including its net financial liabilities, and the present value of the net taxes it would collect from current and future generations were the latter generations to bear the same lifetime fiscal burden as current newborns.

Abstracting from intergenerational considerations, and calculating the accounts of future generations using the same method adopted for current generations, we can compute the intertemporal budget gap (IBG), which captures the size of the imbalance in the intertemporal budget (eq. (1)) with respect to GDP:

$$IBG = \frac{\sum_{s=0}^{\infty} G_{t+s}(1+r)^{-s} + D_t - \sum_{s=0}^{M} N_{t,t-s}P_{t,t-s} - \sum_{s=1}^{\infty} N_{t,t+s}P_{t,t+s}}{GDP} \quad (5)$$

From equations (5) and (4), it follows that the intertemporal budget gap will be lower than the intergenerational balance gap whenever current fiscal policy treats future generations less favourably (in terms of the net lifetime taxes imposed on them) than present newborns.

An alternative way of looking at imbalances is to determine which change in policy is necessary to close the intertemporal or intergenerational gaps. For this purpose, we compute the immediate and permanent percentage increase in total tax revenues needed to achieve intergenerational and intertemporal balance. This tax policy is both sustainable, as it automatically satisfies the government's intertemporal budget constraint, and optimal, in the sense that after such a one-off increase, tax rates are expected to remain constant thereafter and are thus least distortionary (Barro, 1979, and Flemming, 1987). This is our preferred measure since it is easy to interpret and not very sensitive to the assumptions about the growth rate of productivity and the discount rate. GAs are difficult to evaluate in terms of their size and together with IBG/IGG they are very sensitive to the above-mentioned assumptions.

In section 4, the size of these tax increases are used to assess the degree of intergenerational and intertemporal budget imbalances. Before delving into the results, in section 3 we present the assumptions and data used in the construction of the GAs for Scotland.

3. Data and projections

In principle, the calculation of GAs requires only population projections, age profiles for taxes, transfers and public services, a base-year value for government net debt, and assumptions on the discount rate and the real growth rate in productivity. In addition, we use available information on planned policy changes, which are reflected in projected government revenues and spending. The base year for the analysis is 2013. We use 2012-based principal population projections produced by the ONS. Table 1 provides a list of the fiscal items included in the model.[6]

Base year values for benefit items are obtained from the Department for Work and Pensions (2014), while the different categories of government revenues as well as large expenditure items such as health and education spending are taken from Government Expenditure and Revenue Scotland (2015). Projections after 2013 are based on UK-level projections, since no official forecasts are available at the Scottish level. The method used to attribute projections to Scotland relies on the assumption that the Scotland-to-UK ratio of the average age-adjusted amount per person for each tax and expenditure item remains constant over time. This method takes into account the age/gender composition of the population and the age profiles of revenues and expenditures[7].

[6] This level of disaggregation corresponds to the one in Government Expenditure and Revenue Scotland (GERS, 2015).

[7] For a more detailed explanation of the approach followed to obtain these projections, see Appendix A.

Table 1. List of modelled revenues and expenditures.

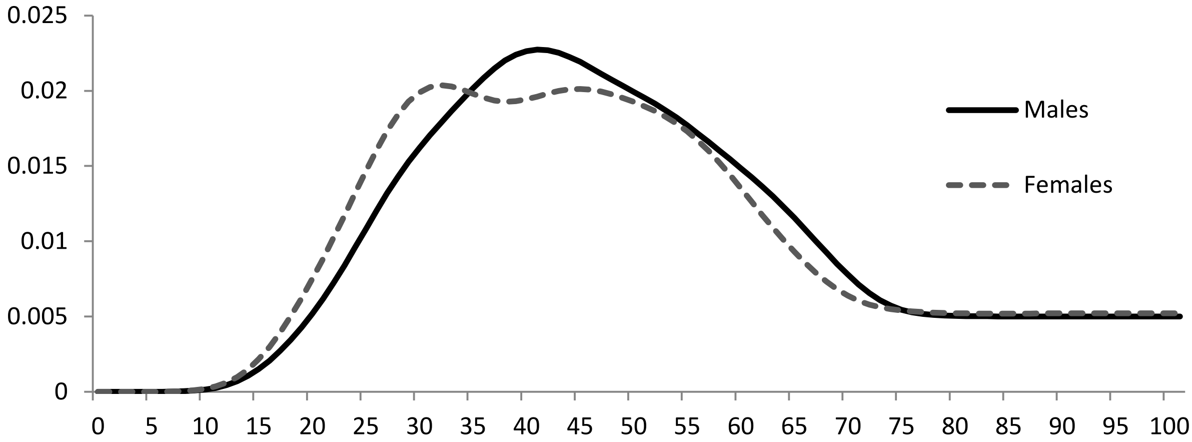
Revenues	Transfers/services
Aggregates levy	Attendance allowance
Air Passenger Duty	Bereavement allowance
Alcohol duties	Carer's allowance
Betting, gaming and lottery	Child benefit
Capital Gains Tax	Disability living allowance
Climate Change Levy	Discretionary housing payments
Corporation Tax	Education
Council Tax	Employment and support allowance
Fuel Duty	Healthcare
Gross Operating Surplus	Housing benefit
Income Tax	Incapacity benefits
Inheritance tax	Income support-unretired
Insurance premium tax	Industrial injury benefit
Interest and Dividends	Jobseeker's allowance
Landfill tax	Maternity Benefits
NI contributions	Unallocated government expenditures
Non-domestic rates	Over 75 TV licence
North Sea revenues	Pension Credit
Other taxes and royalties	Severe disablement allowance
Other taxes on income and wealth	State pension
Rent and other current transfers	Statutory maternity pay
Stamp duties	Winter fuel payments
Tobacco duties	
VAT	
Vehicle Excise duty	

UK level projections produced by the Office for Budget Responsibility (OBR, 2015) are used for all tax items as well as health and education expenditure and are available until 2020. Projections for all categories of benefits are produced by the Department for Work and Pensions (DWP, 2015) and also run until 2020. The path for aggregate expenditures and revenues after 2020 is calculated within the model and depends on population dynamics, age profiles and the growth rate chosen for individual items, which will be discussed in further detail in the next section. Age profiles by gender for taxes and transfers show the age distribution of a specific tax/transfer that an average person of a certain gender pays/receives over her lifetime. The sum of the monetary values paid/received at each age is normalised to one. For benefit profiles we use regional administrative data from the DWP whenever possible[8]. Where administrative data are not available, we use survey data for Scottish households from both the Expenditure and Food Survey (EFS) and the Family

[8] This is the case for a large number of the benefits, where weekly average payments by age and gender can be retrieved from the DWP's tabulation tool: http://tabulation-tool.dwp.gov.uk/100pc/

Resources Survey (FRS)[9]. As an illustration, Figure 1 plots the age profiles of income tax revenue for both males and females in Scotland.

Figure 1. Income tax age-gender profile



The income tax age profiles track labour income closely. Male workers reach the maximum level of income tax payments at around 40 years of age. For females, the profile exhibits a two-peaked shape with a trough between the ages of 30 and 45 associated with childbearing. Soon after retirement age income tax contributions reach very low levels[10].

It is necessary to construct different profiles for males and females, due to differences between genders (e.g. maternity benefits). However, GAs are not constructed for each gender separately as this would neglect important factors at play, such as intra-household redistribution. Thus, the GAs calculated are, effectively, an average of the male and female accounts.

The general rule regarding the age dimension of tax incidences is to assume that taxes are borne by the generations that actually pay them (e.g., income taxes on income and property taxes on property owners) and that they are accounted for in the same period they are paid. For transfers, the rule is to assume that those who receive the transfer coincide with those

[9] In order to sidestep the problem of small sample size afflicting Scottish survey data, we pool together the 2004-2012 waves to construct the EFS-based profiles and the 2008-2012 waves to construct the FRS-based ones. For the specific micro-data source of each age profile, please see Appendix B.

[10] The profiles are roughly constant after age 75 because of profile smoothing and the fact that we assume a flat profile after the age of 82 (due to lack of data).

who benefit from it[11].

We use data from the ONS (2015) on the UK's net debt and calculate its Scottish share in the base year on a population basis. This calculation yields a net debt level of about £124,458 or about 82 per cent of GDP (including a geographical share of North Sea revenues) in 2013[12].

Aggregate projected taxes and transfers between 2013 and 2020 are distributed by age and gender based on age profiles and the population structure. For years between 2020 and 2063 we assume that government receipts and expenditure per person at each age and gender grow at the assumed, exogenous real productivity growth rate. Therefore, total spending or revenue in any category in any given year is equal to the sum over all age groups of per capita expenditures or revenues multiplied by the projected population size of each age group and the assumed real productivity growth rate. The only exception is the state pension. This is the only item for which profiles for both genders are not held constant over time, but, rather, reflect planned changes in the state pension age (SPA). This means that the projected total pension bill is a function not only of changing population, but also of changing entitlement over time. After 2063, when the economy is assumed to reach the steady state, all aggregate amounts grow at the exogenously chosen real productivity growth rate.

4. Scenarios and results

4.1 Baseline scenario

The baseline scenario essentially assumes that Scotland has "full fiscal autonomy" and has to pay for all the growing demands of an ageing population through taxes raised in Scotland. Table 2 presents the GAs under the baseline scenario for the representative individual belonging to each living generation. The main assumptions underlying the baseline scenario are: a) 1.5 per cent real growth in labour productivity from 2020 onwards[13], b) 3 per cent annual real discount rate, c) aggregate growth in unallocated government expenditures of 1.5 per cent.

[11] Child Benefit being the only exception. Even though the claimants are parents and hence the actual cash payment is received by them, this benefit is assumed to accrue to children below the age of 16.
[12] Monetary figures for all years are expressed in 2013 prices.
[13] This assumption is in line with average growth in output per worker in the last thirty years estimated by the ONS (2015).

Table 2. Generational accounts in the baseline scenario (2013 £)*

		Government revenues		Government spending			
Age in 2013	**Total**	**Income tax, NI contributions, VAT and other taxes**	**Other non-tax receipts**	**Healthcare**	**Education**	**Pensions**	**Social Welfare**
FUTURE	410882						
0	182736	456511	2210	-87480	-82826	-52163	-53516
5	193455	468958	2118	-87267	-80920	-53673	-55762
10	218939	512131	2160	-98514	-70047	-64990	-61801
15	240758	515586	2023	-94740	-57548	-61841	-62722
20	251897	472889	1765	-86251	-24722	-56263	-55521
25	238195	438460	1603	-85130	-8373	-57585	-50781
30	202952	407076	1517	-89623	-4855	-63659	-47505
35	157322	369535	1434	-95104	-2822	-72586	-43135
40	112809	322814	1319	-94487	-1886	-77353	-37598
45	64784	272384	1202	-93646	-1424	-81279	-32454
50	14328	223132	1087	-93512	-797	-87395	-28186
55	-44034	173425	967	-92325	-457	-100713	-24931
60	-118221	127662	845	-90164	-69	-133499	-22995
65	-122961	92191	726	-86792	0	-107241	-21845
70	-123897	66645	606	-81623	0	-91570	-17956
75	-116807	49240	495	-75731	0	-77340	-13470
80	-100970	36170	388	-67120	0	-60772	-9636
85	-80692	25915	292	-57656	0	-42553	-6690
90	-47343	18233	219	-48983	0	-12809	-4002
95	-40183	12264	160	-41255	0	-8442	-2910

Table 2 shows that the average individual born in 2013 is expected to make a present value lifetime net contribution to the government finances of about £183K in 2013 prices. The main tax categories are income tax, National Insurance contributions and VAT, whereas the main transfer and public service categories are education and health care.

20-year-olds are expected to make the largest net contribution to the government among all generations. At 20, most of public education spending has already been made and most individuals have the majority of their working life ahead of them, a period in which they will be large net contributors to the Exchequer. It is after the age of 55 that net contributions become negative, due to the onset of pension payments and heavier use of healthcare services. It can also be observed how time discounting affects the present value of each flow: for example, 20-year-olds have the whole of their lifetime pension payments ahead of them, yet the present value of these payments is lower than the one for 60-year-olds. This is because 60-year-olds will receive pension payments in the near future, whereas 20-year-olds need to wait for a long time to benefit from those transfers.

The row labelled 'FUTURE' in the table refers to the constant present value of lifetime net tax payments that future generations would have to make to balance the intertemporal budget were each of them to face exactly the same fiscal burden (i.e. the $\overline{N}$ from equation (3)). To ensure fiscal sustainability, average net contributions need to rise sharply, from £183K for current new-borns, to £411K for future generations. This indicates the existence of a large gap between the level of net contributions that the generation born in 2013 is expected to make and the level compatible with long-term balance in public finances. In addition, since $\overline{N} > N_{t,t}$, future generations will be worse off than the generation born in 2013 if the intertemporal balance is to be satisfied.

4.2 Counterfactual simulations

Another way of measuring the imbalance in fiscal policy is to ask what permanent increase in taxes (or reduction in government spending) is required in order to close either the intergenerational or the intertemporal balance gap. To illustrate such change in fiscal policy, let us compare the baseline scenario with the following set of alternative scenarios: 1) net public Scottish debt equal to zero, 2) changing healthcare expenditure profiles over time reflecting changes in life expectancy and, 3) increase in the growth rate of the average state pension per person from 1.5 to 2 per cent, 4) increase in the real productivity growth rate from 1.5 to 2 per cent, 5) growth in unallocated government expenditures of 1.5 per cent per capita.

Table 3 reports both the GAs and the tax adjustments necessary to satisfy both constraints in all these cases and in the baseline scenario. It shows that, in order to close the intergenerational and intertemporal balance gaps, in the baseline scenario a permanent rise of about 27.1 and 28.1 per cent, respectively, in tax revenue is required. These tax increases represent about 8.3 and 8.5 per cent, respectively, of Scotland's GDP[14]. The reason why restoring intergenerational balance requires a somewhat lower tax increase is due to the fact that, given fiscal and population projections, the projected present value of the net contributions of future generations to the public finances is lower than if all future generations were to contribute exactly the same amount as 2013 new-borns (see eqs. (4) and (5)).

Table 3. Generational accounts and required changes in taxation under alternative scenarios.*

	Generational Accounts		Percentage change in tax revenues needed to restore		Tax change as a percentage of GDP	
	2013 new-born ($N_{t,t}$)	Future generations ($\bar{N}$)	Inter-generational balance	Inter-temporal balance	Inter-generational balance	Inter-temporal balance
Scotland Baseline	£ 182,736	£ 410,822	27.1 %	28.1 %	8.2 %	8.5 %
No Public Debt	£ 182,736	£ 380,351	23.4 %	24.4 %	7.1 %	7.4 %
Healthcare expenditure profiles updated in line with mortality rates	£ 193,418	£ 388,916	23.2 %	24.2 %	7.0 %	7.3 %
2 % growth in average pensions	£ 160,654	£ 426,096	31.5 %	36.7 %	9.5 %	11.1 %
2 % growth in real productivity	£ 205,943	£ 416,942	25.8 %	27.3 %	7.8 %	8.2 %
1.5% per capita growth in unallocated government expenditures	£ 182,736	£ 451,116	31.8 %	32.8 %	9.6 %	9.9 %

*Figures are in 2013 prices. Scottish GDP includes a geographical share of North Sea revenues.

The second scenario presents a counterfactual situation where the Scottish net public debt is set equal to zero. This exercise gives an idea of how much of a burden the existing stock of debt represents relative to the future imbalances. The GA of the generation born in 2013

[14] The implicit assumption here is that future growth of GDP depends on productivity growth and increase in the size of the labour force.

remains the same, since this change does not affect any of the components of equation (2). It, however, does affect the constant GA of future generations. From equation (3) it can be seen that any change in D_t alters the value of $\overline{N}$. The GA of future generations decreases since the total fiscal burden is now lower. The rise in taxation required to close both the intertemporal and intergenerational gaps is now lower. However, the impact is relatively modest because the size of the national debt is relatively small compared with the size of future projected imbalances and because net debt is not linked to productivity growth and therefore its importance relative to other factors quickly diminishes over time.

The third scenario incorporates changing healthcare expenditure age profiles over time based on projected improvements in life expectancy, as opposed to the fixed age profiles assumed in the baseline scenario. This is to illustrate the effects of assuming that healthcare spending depends not only on age but also on proximity to death, a view which is gaining support from a growing body of literature (Zweifel et al, 1999; 2004; Grey, 2005). To account for increasing life expectancy we adjust healthcare spending profiles for future years according to the methodology used in Lisenkova and Mérette (2014). We assume that a one year increase in life expectancy corresponds to a one year increase in healthy life expectancy. Starting at the age of 50, a one year increase in longevity is assumed to result in a shift of the healthcare profile back by one year. With the lower overall expenditure on healthcare that this change implies, it can be seen that the GA of the generation born in 2013 increases, as their net lifetime contribution rises due to lower expected use of public healthcare services compared to baseline. Since the healthcare cost of the future elderly is now lower compared to baseline, both presently alive and future generations have higher net lifetime contributions, reducing the required per capita contribution of future generations ($\overline{N}$). The fall in both the intertemporal and intergenerational budget gaps leads to a decline in the tax rate rises needed to achieve balance in both cases which is similar in magnitude to the increases needed in the previous scenario.

In the fourth scenario, we investigate the impact of raising the rate of growth in the average real state pension per person by 0.5 percentage points with respect to baseline, to 2 per cent. This simulation tries to illustrate the possible consequences of the “triple lock” system, which guarantees that state pensions will continue to grow by the highest among the inflation rate, the growth rate in the average wage or 2.5 per cent. In situations where there is both low inflation and low productivity growth (reflected in wages), this policy will result in real pensions growing faster than productivity, which will lead to additional fiscal pressure. Faster growth in pensions than in productivity leads to a surge in the present value of the pension bill, which benefits living generations in 2013 at the expense of future generations, who now have to bear a higher tax burden in order for the intertemporal budget constraint to be satisfied. The intergenerational gap, however, rises to a lesser extent than the intertemporal gap. This happens because future generations are expected to enjoy a longer life expectancy and will thus benefit from higher pensions for longer.

The fifth scenario raises the assumed exogenous productivity growth rate to 2 per cent. The effect of such change is not straightforward because an increase in productivity leads to higher future benefits and expenditures on public services as well as tax revenues. However, the overall effect on the public finances is positive and the required tax increases are modestly smaller.

Finally, the last row shows the results of assuming that unallocated government expenditures grow in line with population. This is done by setting their growth rate at 1.5 per cent per capita, instead of 1.5 per cent in aggregate. The results are very sensitive to this assumption because of the large weight of these expenditures in overall public spending. Unallocated expenditures include a variety of items for which we do not have detailed information and/or projections and which are harder to attribute to individuals. Some of them should be less sensitive to the size of the population (thus implying economies of scale), like defence; while others should be more affected by the size of the population, like spending on transport and housing. Since the Scottish population is expected to grow during the simulation period, this change leads to an increase in the present value of unallocated government expenditures, which now grow at a faster rate. This assumption adds 1.4 percentage points of GDP both intertemporal and intergenerational budget gaps.

4.3 Comparison with the UK

The results presented in the previous subsection suggest that, under current policy, the Scottish fiscal situation is both generationally unequal and fiscally unsustainable. To put the size of imbalances into perspective, we compare the Scottish case with that of the whole of the UK. We construct a baseline scenario for the whole of the UK under the same assumptions as in the Scottish case. We show two variants of a baseline scenario for the UK and Scotland: one where unallocated expenditures (UE) grow in line with population, at 1.5

per cent per person, and another one where they are independent of population growth and are assumed to grow at 1.5 per cent in aggregate. As we demonstrate in the previous section this assumption influences the results substantially. It also highlights an important difference between Scotland and the UK as a whole. Table 4 compares two sets of baseline scenarios, together with a number of counterfactual scenarios where the main factors behind the differences between Scotland and the UK are added one at a time.

Table 4. Generational accounts and required change in taxation in Scotland and the UK.*

	Generational Accounts			Tax change as a percentage of GDP			
	2013 new-born ($N_{t,t}$)	Future generations ($\bar{N}$)		Inter-generational balance	Inter-temporal balance	Inter-generational balance	Inter-temporal balance
		UE do not depend on population	UE depend on population	UE do not depend on population		UE depend on population	
Scotland Baseline	£ 182,736	£ 410,822	£ 451,116	8.2 %	8.5 %	9.6 %	9.9 %
Fixed NS revenues in 2013-20, then 1.5% growth	£ 182,736	£ 355,243	£ 395,477	6.2 %	6.5 %	7.6 %	7.9 %
Fixed NS revenues 2013-20, then 1.5% growth + deficits in 2013-2020 equal to UK's (as a percentage of GDP)	£ 182,736	£ 257,065	£ 290,146	2.7 %	2.9 %	3.9 %	4 %
Fixed NS revenues 2013-20, then 1.5% growth + deficits in 2013-2020 equal to UK's (as a percentage of GDP) + UK population structure	£ 165,565	£ 234,295	£ 264,305	2.7 %	2.6 %	3.9 %	3.8 %
UK Baseline	£ 211,414	£ 241,455	£ 293,869	1.2 %	1.6 %	3.3 %	3.7 %

*Figures are in 2013 prices. Scottish GDP includes a geographical share of North Sea revenues.

Comparing the UK baseline with the Scotland baseline, we observe that the GA of the generation born in 2013 is about £30K higher in the UK compared to Scotland. The main reasons for this are higher level of age-adjusted per capita spending on pensions and education and a lower level of per capita income tax revenues in Scotland. There exist, however, some counteracting factors, such as lower life expectancy in Scotland, which means that people receive pensions and use healthcare services for a shorter period of time on average. However, observed differences in per capita spending and revenue dominate.

At the same time, the GA of future generations required to achieve intertemporal balance in Scotland is about £160K-170K higher than in the UK, depending on the assumed growth rate of unallocated expenditures. This larger gap between the net contributions of currently alive generations and the required contributions of future generations in Scotland results in a larger change in tax policy necessary to achieve intertemporal balance. In fact, Scotland would need to raise about three to five times as much in taxes, as a percentage of GDP, compared with the whole of the UK if it were to close the intertemporal gap. Next we discuss the main differences between Scotland and the whole of the UK that lie behind this result.

First, the latest OBR forecasts anticipate a drastic reduction in North Sea tax revenues of about 89 per cent from 2013 to 2020, given the recent downward trend in oil prices and falling production. Since about 84 per cent of all North Sea revenues in the UK are attributable to Scotland (based on a geographical principle), this downward revision negatively affects the Scottish fiscal outlook to a much greater extent than the UK's. In fact, a simulation that keeps North Sea revenues projections constant at the 2013 level from 2013 to 2020, shown in the second row of Table 4, results in a reduction of the permanent tax revenue increase required to achieve intertemporal balance of about 2 percentage points of GDP.

Second, Scotland starts with a deficit of 8.1 per cent of GDP in the 2013 base year, while the one for the UK is 5.6 per cent of GDP. According to OBR projections, which reflect current consolidation plans, the UK is expected to substantially improve its fiscal position and reach a small budget surplus in 2020. By contrast, our projections for Scotland, preserving currently observed differences in the average age-adjusted per capita amounts in revenues and expenditures, suggest that it will run a deficit for all the years in the simulation period. From 2020 onwards, fiscal balances in both the UK and Scotland worsen, but since the UK is expected to reach a surplus in 2020, the initial departure point is worse for Scotland and so the gap between the UK and Scottish deficits tends to widen over time. In the third row of Table 4, the fiscal deficits relative to GDP for Scotland in the period 2013-2020 are set equal to the ones forecasted for the UK. This new assumption lowers the permanent tax rise needed to close the intertemporal budget gap by 3.5 to 4 percentage points of GDP, revealing the crucial role played by the different fiscal outlooks between Scotland and the UK.

Third, the Scottish population is relatively older than the UK population as a whole, which implies, all else being equal, less favourable conditions for the sustainability of the public finances. However, the differences in the age structure of the population play a very limited role, as reflected in the fourth row of Table 4, which shows the effects of applying the UK population structure to Scotland. Even though the GA for future cohorts falls relative to the previous scenario, so does the GA for the generation born in 2013, due to longer life expectancy compared to the baseline and the additional pension and healthcare costs associated with it. This implies that although the intertemporal budget gap declines somewhat, the size of the relative reduction in the two GAs actually renders the intergenerational budget gap slightly wider relative to the baseline scenario. The effect is, however, rather minor.

After adjusting for very uncertain projections for North Sea revenues and the starting fiscal position, the rest of the fiscal imbalances can be attributed to demographic pressures associated with population ageing. Relatively smaller future working age cohorts will have to pay for all the demands of a relatively larger and older population. Comparing the difference between the previous scenario and the UK baselines two confounding factors can be identified. First, Scotland has higher costs associated with ageing population due to the structure of its public expenditures. For example, its age-adjusted per capita pensions are almost 11 per cent higher than in the UK. At the same time Scotland's income tax receipts are about 15 per cent lower in age-adjusted per capita terms that in the UK. This contributes about 1 percentage point of GDP to the difference between the UK's and Scotland's intertemporal gap, which can be seen in the scenario where unallocated public expenditure are insensitive to population growth. Second, the growth rate of unallocated public expenditures plays an important role and favours the UK. In the scenario where they grow in line with population, faster population growth in the UK is masking the differences in age-adjusted public spending between the UK and Scotland. In this case intertemporal budget gap in the UK and Scotland after controlling for the decline in North Sea revenues and initial fiscal deficit is practically the same. Put differently, if we assume that unallocated public spending does not depend on the growth rate of population, the benefits for the UK from economies of scale relative to Scotland are about 1 percentage point of GDP.

4.4 Current devolution plans

So far we have modelled Scotland as if it had "full fiscal autonomy". In this subsection, we investigate the implications for the Scottish public finances of current mid-term devolution plans as envisaged in the Scotland Act 2012 and the Smith Commission report (2014). This corresponds to where the current fiscal arrangement between the Treasury and the Scottish government stands nowadays and how it is expected to evolve in the near future. Thus, it corresponds to the situation where Scotland is a region within the UK with increasing, albeit not full, fiscal powers.

According to these plans, further taxation powers will be devolved to Scotland in two waves: a first devolution package in 2015/16 will give Scotland full autonomy over Landfill Tax and Land and Buildings Transactions Tax and a second devolution wave, in 2016/17, will include the Scottish Rate of Income Tax (SRIT). Although subject to uncertainty, there are also plans for a third devolution wave in which Scotland will fully administer income tax, air passenger duty and aggregates levy as well as gross VAT by 2018/19. Benefits to be devolved in that fiscal year include attendance allowance, carer's allowance, disability living allowance, industrial injuries disablement benefit, personal independence payment, severe disablement allowance, cold weather payment, funeral payment, sure start maternity grant and winter fuel payment. All these items will add to the list of already devolved items such as council tax and non-domestic rates. For an extensive discussion, see Bell and Eiser (2014).

Under current arrangements, the Scottish government receives a transfer from the Treasury that is meant to cover any devolved spending in excess of devolved revenues. This transfer is called the block grant. Changes in the set of devolved taxes and benefits over time imply adjustments to the block grant. At the moment it is hard to predict the principle behind the block grant adjustment, because it will be a subject of negotiations between the Treasury and the Scottish Government. To estimate and project the block grant we use the methodology described in Bell and Eiser (2014) and update the data using the latest OBR (2015) projections. We treat the block grant as any other revenue item.

Given the timeline for the devolution of fiscal powers, we calculate the GAs and intertemporal and intergenerational budget gaps in the model. This means that, at first, only items that were devolved as of 2013 are included, and in later years newly devolved items are added in accordance with current plans, which set out a tentative devolution roadmap until 2020. Projections for most devolved items until that year follow the logic described for our baseline scenario based on maintaining the Scotland-to-UK ratio of average age-adjusted per capita tax and benefit levels constant across time. From then onwards, all items are assumed to grow at a 1.5 per cent real per capita growth rate[15].

We construct a scenario where we apply the same principle as in the current Barnett formula to calculate changes over time to the Scottish block grant. These changes are a function of the increases in spending in each government department at the UK level multiplied by the relative size of the projected population for Scotland and England[16]. The addition/subtraction to the Block Grant resulting from the Barnett formula is further modified by the introduction of newly devolved taxes and benefits in the following manner: the estimated value of newly devolved tax revenues is subtracted from the amount resulting from the Barnett formula, while the estimated value of newly devolved benefits is added to this amount. Hence, the final change in the Block Grant over the projected years is the result of both the application of the Barnett formula and the assumptions regarding the timing and size of future fiscal devolution packages. From 2063 onwards, the block grant is assumed to grow at 1.5 per cent per capita in real terms, in line with the rest of the items. Table 5 presents the results of the generational accounting exercise for the devolved Scottish public finances using these assumptions as well as the Scottish and UK baselines from the previous subsection for comparison.

The interpretation of the GAs in the devolved scenarios has to be done carefully. Scottish people are still paying the same taxes and are receiving the same level of public transfers and services as in the baseline scenario. The difference is in the destination/origin of those taxes and transfers. In the baseline scenario, the Scottish government is assumed to receive all taxes and make all transfers to its citizens. In the devolved scenarios, the Scottish government only receives some taxes and makes some transfers. Thus, the GAs in the devolved scenario show the net contributor/beneficiary position of different generations *vis-a-vis* the Scottish government.

[15] See Appendix C for details on each devolved item, the timing of their incorporation into the model and the method followed for projections.
[16] For more details on block grant projections see appendix C.

Table 5. Generational accounts and required change in taxation under devolved and baseline scenarios.*

	Generational Accounts			Tax change as a percentage of GDP			
	2013 new-born ($N_{t,t}$)	Future generations ($\bar{N}$)		Inter-generational balance	Inter-temporal balance	Inter-generational balance	Inter-temporal balance
		UE do not depend on population	UE depend on population	UE do not depend on population		UE depend on population	
Devolved Scenario	£ 40,093	£ 133,217	£ 144,728	3.9 %	4.7 %	4.4 %	5.2 %
Scotland Baseline	£ 182,736	£ 410,822	£ 451,116	8.2 %	8.5 %	9.6 %	9.9 %
UK Baseline	£ 211,414	£ 241,455	£ 293,869	1.2 %	1.6 %	3.3 %	3.7 %

*Figures are in 2013 prices. Scottish GDP includes a geographical share of North Sea revenues.

The results show that the GAs of the generation born in 2013 and that of future generations that would be needed to close the intertemporal budget gap are much lower than in the baseline scenario where Scotland is assumed to have “full fiscal autonomy". The same is true about the size of the required tax adjustment. This is due to the smaller size of the devolved public sector.

One interesting result is that if we add the size of the required tax increase in the UK and in the devolved Scotland scenario together, then the resulting tax increase would be about 1 to 2 percentage points of GDP lower (depending on the assumption about the unallocated public expenditures) than in the case of a “fiscally independent” Scotland. This suggests to us that, from a purely fiscal point of view, Scotland is in a better position without “full fiscal autonomy”. The main reason for this is that the effect of falling North Sea revenues gets diluted across the whole of the UK, since in the devolved scenario they are not part of Scottish government revenues. Larger difference for Scotland in the scenario where unallocated expenditures do not depend on the growth rate of population is because in this case Scotland also benefits from UK wide economies of scale.

However, a note of caution in the interpretation of these results is in order as they are very sensitive to the path followed by the Block Grant which depends on the exact outcome of the negotiations between the Treasury and the Scottish government. There is thus an important degree of uncertainty surrounding the evolution of the Block Grant as well as the composition of future devolution packages.

5. Conclusions

This paper presents the first set of GAs for Scotland and analyses the impact on fiscal sustainability and intergenerational equality of current and projected public expenditures and revenues. It also explores different scenarios and their implications for Scotland's fiscal position.

Our results indicate that the current fiscal situation is unsustainable, since without a change in the present trajectory of fiscal policy, the government deficit would not be eliminated in the long-run. It is also generationally unbalanced, since the responsibility to close the intertemporal budget gap (partly generated by present generations) falls disproportionately on future generations. Given these imbalances, we find that removing both the intertemporal and intergenerational gaps requires a substantial increase in tax revenue, and/or a reduction in general government expenditure, public services and welfare transfers.

The results are sensitive to a number of important assumptions. Counterfactual simulations that vary these assumptions and a comparison with the UK as a whole allow us to evaluate their relative importance. Despite uncertainties inevitably associated with any analysis attempting to evaluate long-term processes, this exercise allows us to arrive at some valuable conclusions.

First, if Scotland had “full fiscal autonomy”, its fiscal position would be very vulnerable because of the high exposure to very uncertain future North Sea revenues. We are using OBR projections which anticipate that North Sea revenues will decline by 89 per cent between 2013 and 2020. To cover for this loss, a permanent increase in taxation or a reduction in government spending in the order of 2 per cent of GDP would be required.

Second, initial fiscal deficits are very important if they are of a structural rather than a cyclical nature. Scotland has a less favourable starting fiscal position compared with the UK as a whole, and this contributes about 4 percentage points of GDP to the required permanent increase in taxes or reduction in government spending.

Third, after controlling for North Sea revenue decline and worse starting position, the difference in future imbalances associated with population ageing between Scotland and the whole of the UK is up to 1 percentage point of GDP. These demographic pressures add

2.5 to 4 percentage points of Scottish GDP to the required permanent increase in taxation or reduction in spending.

Fourth, if we assume that there are economies of scale in provision of public services (in our example this amounts to saying that unallocated government expenditures do not depend on population growth), then Scotland's intertemporal budget gap is reduced by about 1 percentage point of GDP and UK's by about 2 percentage points of GDP.

Fifth, other factors that are often discussed in the context of Scottish fiscal autonomy – the size of the public debt and a worse demographic outlook compared with the UK as a whole – have modest to negligible effects on the sustainability of the Scottish public finances.

Sixth, pension indexation rules have a very important impact on the long run sustainability of the public finances. We demonstrate that under certain circumstances the current triple lock guarantee can add an additional 3 percentage points of GDP to the required permanent increase in taxation.

Seventh, healthcare expenditure is another large spending item which will grow substantially with population ageing. It is very important to be able to project it correctly. Methods that take into account not only age but also proximity to death are preferable and produce lower estimates of the overall level of healthcare spending. We tried to control for increasing longevity but were not able to use more sophisticated methods that directly account for proximity to death. The reason is a lack of estimates distinguishing between age and proximity to death effects in the UK. We hope that the topical nature of this issue will prompt more research in this area.

Eighth, current devolution plans might result in a lower overall tax burden in Scotland (devolved plus UK-wide tax increases) compared with the scenario with "full fiscal autonomy". But these results are very sensitive to the assumptions on the block grant adjustments that will follow new devolved powers, which are very uncertain at the moment.

Finally, it is worth reminding that the model is based on a simple accounting exercise that computes the size of the gaps and asks how much more overall tax revenue would be needed to close them. This ignores potential behavioural responses to changes in taxation that may offset the tax increases and/or underestimate the size of the rise in taxation needed. The model is however useful in quantifying the likely size of fiscal challenges and the potential size of policy changes needed to overcome them.

Appendix

A

For calculating the aggregate projections for Scotland for each transfer and tax item for the 2013-2020 period, we:

1) Use the DWP (2015) for projections of public transfers, and the OBR (2015) for forecasts of the main tax items. Both of these sets of projections are at the UK level.
2) Compute the Scottish-to-UK ratio of the average age-adjusted per capita amount for every item in the 2013 base year using aggregate values, population projections and age profiles.
3) Assume the ratio for every item stays constant over time. Use the UK-level aggregate projections for 2014-2020 for each item and population projections to arrive at the Scottish aggregate projection for each item.

Algebraically, this procedure can be described as follows. Let $x_{i,t,SCO}$ and $x_{i,t,UK}$ denote the average age-adjusted per capita amount for item *i* in year *t* in Scotland and the UK, respectively. This is defined for both Scotland and the UK as:

$$x_{i,t} = \frac{T_{i,t}}{\sum_{g=0}^{101} P_{g,t} * a_{i,g}}$$

Where T_i is aggregate amount of item *i*, $a_{i,g}$ is the value of the profile for the specific item *i* at age *g* and P_g is the number of people at age *g.*

In the base year, 2013, we calculate the average age-adjusted per capita amount for item *i* in both Scotland and the UK. Then, for any *t* from 2013 to 2020, we make use of the $\frac{x_{i,2013,SCO}}{x_{i,2013,UK}}$ ratio to calculate the projected aggregate amount for Scotland as follows:

$$T_{i,t,SCO} = \frac{x_{i,2013,SCO}}{x_{i,2013,UK}} * x_{i,t,UK} \sum_{i=0}^{101} P_{g,t} * a_{i,g}$$

B

The following are the sources of data for estimating the age-gender profiles of each item:

Tax profiles:

Alcohol duties	EFS
Betting, gaming and lottery duties	EFS
Capital gain tax	EFS
Corporation tax	EFS

Council tax	EFS
Fuel duty	EFS
Income tax	EFS
Insurance premium tax	EFS
National Insurance contributions	EFS
Other taxes on income and wealth	EFS
Stamp duties	EFS
Tobacco duties	EFS
Value Added Tax	EFS
Vehicle Excise duty	EFS
Inheritance tax	ONS
Aggregates levy	flat profile
Interest and Dividends	flat profile
Landfill tax	flat profile
Other taxes and royalties	flat profile
Rent and other current transfers	flat profile
Gross operating surplus	unallocated across age and gender
North Sea Revenues	unallocated across age and gender

Transfer/benefit profiles:

Basic State pension	DWP
Bereavement allowance	DWP
Carer's allowance	DWP
Disability living allowance	DWP
Discretionary Housing payments	DWP
Child benefit	EFS
Education	EFS
Health	EFS
Housing benefit	EFS
Incapacity benefit	EFS
Income support (unretired)	EFS
Industrial injury disablement benefit	EFS
Maternity benefit	EFS
Pension credit	EFS
Statutory Maternity Pay	EFS
Employment and Support allowance	FRS
Jobseeker's allowance	FRS
Winter fuel payments	FRS
Unallocated government expenditure	unallocated across age and gender

C

The following table lists the number of items included in the calculation of the GAs under the devolved scenario and provides information on their year of incorporation and the method employed for projections:

	Year introduced	**Projection method for 2013-20**
AME (Annually Managed	2013	Methodology as in Bell and Eiser (2014)

Expenditure)		
Block Grant	2013	Methodology as in Bell and Eiser (2014)
Non-domestic rates	2013	Same as baseline scenario
Land and Buildings Transactions Tax	2015	Forecasts available in
Landfill Tax	2015	Same as baseline scenario
Aggregates Levy	2018	Same as baseline scenario
Air Passenger Duty	2018	Same as baseline scenario
Gross VAT	2018	GERS (2015) for 2013 value. Then, same methodology as in baseline scenario (using total VAT projected growth rates). This item is equal to 50 per cent of full VAT.
Income tax	Scottish Rate of Income Tax for 2016 and 2017. Then,income tax on non-savings, non-dividends	GERS (2015) for 2013 value. Projections until 2018 from table 2.4 in
Agriculture, forestry and fisheries	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Defence	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Education	2013	Same as baseline scenario
Enterprise and Economic Development	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Environment Protection	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Health	2013	Same as baseline scenario
Housing and Community Amenities	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Public and Common Services	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Public Order and Safety	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Recreation, Culture and Religion	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Science and Technology	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Social protection	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Transport	2013	GERS (2015) for 2013 value. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Unallocated government expenditures	2013	Equal to Accounting Adjustments in GERS (2015) plus a balancing item to make the deficit in 2013 equal to zero. Then growth rate for *unallocated government expenditure* from baseline scenario applied.
Attendance allowances	2018	Same as baseline scenario
Carer's allowance	2018	Same as baseline scenario
Cold Weather Payment	2018	Methodology as in Bell and Eiser (2014)
Disability living allowances	2018	Same as baseline scenario
Funeral Payment	2018	Methodology as in Bell and Eiser (2014)

Industrial injury disablement benefit	2018	Same as baseline scenario
Personal Independence Payment	2018	Methodology as in Bell and Eiser (2014)
Severe disablement allowance	2018	Same as baseline scenario
Sure Start Maternity Grant	2018	Methodology as in Bell and Eiser (2014)

Age profiles for the block grant were calculated as a residual from the difference between total contributions at each age and contributions to devolved items only (in pounds). This gives the contributions in pounds per person at every age for reserved taxes, which are used as a proxy to estimate the shape of a hypothetical age profile for the block grant, which is treated as any other tax item.

It is also important to note that in this scenario the total debt is assumed equal to the level under the baseline scenario (i.e., assigned to Scotland on a population basis).

REFERENCES

Amior, M., Crawford, R. and Tetlow, G. (2013). "Fiscal Sustainability of an Independent Scotland", *IFS Reports (88)*.

Auerbach, A., Gokhale, J. and Kotlikoff, L. (1991). "Generational accounts: a meaningful alternative to deficit accounting", in (D. Bradford, ed.), *Tax Policy and the Economy*, vol. 5, Cambridge, MA: MIT Press, pp. 55-110.

Barro, R. (1979). "On the determination of the public debt", *Journal of Political Economy*, vol. 87(5), pp. 940-71.

Bell, D. and Eiser, D. (2014). "Funding Smith - Budget 2018: Evidence to the Devolution (Further Powers) Committee", Centre on Constitutional Change: http://www.centreonconstitutionalchange.ac.uk/blog/funding-smith-budget-2018-evidence-devolution-further-powers-committee

Cardarelli, R., Sefton, J. and Kotlifkoff, L. (2000) "Generational Accounting in the UK", *The Economic Journal*, 110 (November), pp. F547-F574.

Department for Work and Pensions. (2014). *Benefit expenditure by region from 2000/01 to 2013/14*.

Department for Work and Pensions. (2015). *Outturn and forecast budget 2015*.

Flemming, J. (1987). "Debt and taxes in war and peace: the case of a small open economy". in M. J. Boskin, J. Flemming and S. Gorini eds., *Private Saving and Public Debt.* Oxford: Basil Blackwell.

Gray, A. (2005). "Population Ageing and Healthcare Expenditure", *Ageing Horizons,* No. 2, pp. 15–20.

Kotlikoff, L. (1992). "Generational Accounting: Knowing Who Pays, and When, for What We Spend"*,* New York, N.Y.: The Free Press.

Lisenkova, K. and Mérette, M. (2014). "Can an Ageing Scotland Afford Independence?" *National Institute Economic Review*, no 227, pp. R32-R39

McCarthy, D., Sefton, J. and Weale, M. (2011). "Generational Accounts for the United Kingdom", *NIESR Discussion Paper* no. 377.

Office for Budget Responsibility. (July, 2015). *Economic and Fiscal Outlook*.

Office for National Statistics. (July, 2015). *Public Sector Finances*.

Office for National Statistics. (October, 2015). *Productivity Measures.*

Scotland Act (2012).

The Smith Commission. (2014). *Report of the Smith Commission for further devolution of powers to the Scottish Parliament*.

Zweifel, P., Felder, S., and Meiers, M. (1999). “Ageing of population and healthcare expenditure: A red herring?”, *Health Economics*, No 8, pp. 485–496.

Zweifel, P., Felder, S., and Werblow, A. (2004). “Population Ageing and Healthcare Expenditure: New Evidence on the ‘‘Red Herring’’”, *The Geneva Papers on Risk and Insurance*, vol. 29, No. 4, pp. 652–666.