Abstract

Using microsimulation techniques, parametric and non-parametric methods, we decompose changes in the entire distribution of household disposable income in the UK in 2001-11 due to fiscal policy changes (policy effects), benefit take-up (take-up effect), changes in population characteristics and the returns to these characteristics (non-policy effect). We also isolate the automatic stabilisation effect of the tax-benefit system. The paper builds on the current literature, which has examined the effect of fiscal policy changes on the income distribution without explaining the non-policy effects. We decompose the pre-recession (2001-07) and recession (2007-11) periods separately. Our results are consistent with the existing evidence showing that policy effects in the UK have reduced the level of income inequality while non-policy effects have increased it. Non-policy effects explain a significant share of the changes in household disposable income. For example, in both periods higher education expansion has lead to income increases for the richest decile groups and so, to increased income inequality. Finally, the increased level of inequality due to the non-policy effects would have been even higher if it was not for the automatic stabilisation effect of the tax-benefit system.
Keywords: decomposition, parametric and non-parametric methods, microsimulation, income distribution, policy and non-policy effects

JEL codes: D31, H23, H53
1 Introduction

Household disposable income can be regarded as a function of several attributes: individual and household characteristics, the returns to these characteristics (e.g. in terms of wages) and the tax-benefit system. Between 2001 and 2011 in the UK, there have been various changes to these attributes. For example, in regard to earnings we have seen a decline in real full-time weekly earnings between 2007 and 2013 and narrowing of the gender gap for median full-time weekly earnings (\(^?\)). There has been a large increase in the proportion of tertiary students, part-time male workers and ethnic minority groups (author’s calculations using the Family Resources Survey). When it comes to fiscal policies, examples of the changes in the period are the real increase in the National Minimum Wage, the reforms to Child and Working Tax Credits, and the increase in the top marginal tax rate. All these changes have resulted in stable income inequality level and a small decline in relative poverty (\(^?\)).

In recent years, there has been growing literature on income decomposition that has tried to disentangle the effects of different factors on poverty and inequality. It has paid particular focus on the UK and on the effect of tax-benefit policy changes vs 'other' things (see (\(^?\)); (\(^?\)); (\(^?\)); (\(^?\)); (\(^?\)); (\(^?\))). The evidence suggests that the direct effect of policy changes has been to reduce poverty and inequality, while 'other' things lead to the opposite results. What is the effect of 'other things' a result of, remains to be addressed.

There is also a large body of literature that focuses on changes in wages and employment (see e.g. (\(^?\)), (\(^?\)), (\(^?\))). However, this literature does not consider how changes in wages and employment translate into changes in the entire household disposable income. The automatic stabilisation effect of the tax-benefit system has not yet been fully quantified.

This paper tries to address the gaps in the literature. To our knowledge, it is the first one to decompose changes in the entire distribution of household disposable income in the UK in 2001-11 due to fiscal policy changes (policy effects), benefit take-up (take-up effect), changes in population characteristics and the returns to these characteristics (non-policy effect). It also isolates the automatic stabilisation effect of the tax-benefit system. The paper builds on the existing decomposition literature and combines the use of microsimulation techniques (see (\(^?\))) and parametric and non-parametric methods (see (\(^?\))). We decompose the pre-recession (2001-07) and recession (2007-11) periods separately.

Our results are consistent with the existing evidence showing that policy effects in the UK have reduced the level of income inequality while non-policy effects have
increased it. Non-policy effects explain a significant share of the changes in household disposable income. For example, in both periods higher education expansion has lead to income increases for the richest decile groups and so, to increased income inequality. Internal migration (moving out of London) has lead to significant income increases, but these have been almost entirely off set by the negative income effects from immigration. Finally, the increased level of inequality due to the non-policy effects would have been even higher if it was not for the automatic stabilisation effect of the tax-benefit system. We highlight the role of the tax-benefit system in reducing income inequality, which may be bigger than previously thought in the literature.

The next section explains the decomposition methodology we adopt. Section 3 describes the household micro data used in the analysis. Section 4 presents the results and section 5 concludes.

2 Methodology

We use microsimulation techniques, parametric and non-parametric methods to decompose changes in the UK distribution of household disposable income in the 2000’s. The real change, net of price inflation (CPI), in household disposable income between two periods can be attributed to a direct policy effect that stems from changes to the tax and benefit system; benefit take-up effect that consists of changes in the assumptions we make on benefit take-up; and non-policy effect that consists of changes in the individual and household characteristics and the returns to those characteristics. Assuming no behavioural responses to policies, the policy and take-up effect capture the total effect of policies on the income distribution. If, however, households modify their behaviour as a response to policies, this is captured in the non-policy effect and is not disentangled from other changes. Furthermore, the changes in the household disposable income as part of the non-policy effect capture changes to market incomes as well as changes to taxes and benefits due to the automatic stabilisation effect of the tax-benefit system.

We decompose the total change in the income distribution by using purely statistical counterfactual scenarios which show the effect of each component in turn. To do that, we combine two decomposition approaches by (?) and (?). The decomposition is carried out in three steps. In step 1, we start from the actual income distribution in period 1. In step 2, we create a counterfactual scenario in which one of the factors from period 1 is modified to mimic the one in period 0. In step 3, we repeat step 2 cumulatively for all attributes until we arrive at the actual income distribution in period 0.
Following the notation in (?), let us denote with $d$ the structure of tax-benefit system, $p$ the monetary policy parameters of the system and $y$ market incomes and population characteristics. The distribution (i.e. a vector) of household disposable income is expressed as $d(p, y)$, where $d$ transforms $p$ and $y$ into household disposable income. Let us now consider an index $I$ which is a function of the income distribution, e.g. Gini coefficient as a measure of inequality, poverty rate, income decile, average income by different income sources or household type etc. The change in the index $I$ between two periods (0 and 1) is then

$$\Delta I = I[d_1(p_1, y_1)] - I[d_0(p_0, y_0)]$$

(1)

As next, the total change can be decomposed into direct policy effect, take-up effect, non-policy effect and nominal effect (CPI). The decomposition is path-dependent, meaning that the order of components matters and there are alternative combinations. Thus, the total change in $I$ can be decomposed by conditioning the policy effect either on end-period or start-period market incomes and population characteristics data ($y$). In this paper, we will consider only the former. The formal notation is:

$$\Delta I = I[d_1(p_1, y_1)] - I[d_0^{u1}(\alpha p_0, y_1)]$$

Policy effect conditional on data 1

$$+ I[d_0^{u1}(\alpha p_0, y_1)] - I[d_0(\alpha p_0, y_1)]$$

Take-up effect conditional on data 1

$$+ I[d_0(\alpha p_0, y_1)] - I[d_0(\alpha p_0, \alpha y_0)]$$

Non-policy effect conditional on policy and take-up 0

$$+ I[d_0(\alpha p_0, \alpha y_0)] - I[d_0(p_0, y_0)]$$

Nominal effect conditional on policy and take-up 0

(2)

In the next subsections we explain in detail how the effects are calculated.

2.1 The policy and take-up effects

To calculate the direct policy and take-up effects we use the tax-benefit microsimulation model EUROMOD. The model operates on household survey data which
contains information on household and individual socio-economic characteristics and on different income sources. Using the data, EUROMOD calculates benefit entitlements and tax and social insurance liabilities at the individual and household level and household disposable income (for detailed information on the model see (1)). For more information on the UK model see the UK EUROMOD Country Report.2

To calculate the direct policy effect, we keep market incomes and population characteristics constant as of period 1 and alter the tax-benefit rules and monetary policy parameters by taking them from period 1 and 0 in turn. The first term \( (d_1(p_1, y_1)) \) yields the actual household income distribution in period 1, while the second term \( (d_0 u^1(\alpha p_0, y_1)) \) represents a purely statistical counterfactual income distribution. Thus, we create a ’controlled’ experiment to isolate the direct policy effect.

To calculate the take-up effect, we keep market incomes, population characteristics as well as policies the same and apply in turn different benefit take-up rates. In the first component \( d_0 u^1(\alpha p_0, y_1) \) the take-up rates are as of period 1 while in the second component \( d_0(\alpha p_0, y_1) \) the take-up rates are as of period 0. We do not model any take-up behavior but simply the change in the take-up assumptions. The take-up rates are taken from the reports produced by the Department for Work and Pensions (DWP) and the UK’s tax authority Her Majesty’s Revenue and Customs (HMRC).3

2.2 The non-policy effect

Moving to the non-policy effect, it is estimated based on the design and the monetary policy parameters from period 0. Using parametric and non-parametric methods we decompose changes in the distribution of income over time due to changes in the

\(^1(?) \) extend the decomposition framework by (?) and split the policy effect into two more components - indexation effect and structural changes. The former is estimating the effect of changes to the monetary policy parameters (tax thresholds and benefit amounts) and captures actual fiscal drag and benefit erosion, while the latter estimates the effect to changes in the structure of the tax-benefit system such as e.g. introducing a new benefit or revising the income tax schedule. The paper estimates the effect of policy changes in a cross-national perspective and covers the same period 2001-11. The rationale for this decomposition is to understand the nature of the policy changes in the period and estimate their size and progressivity. In contrast to their paper, we look at the aggregate policy effect and focus on the non-policy effect.

\(^2\)Available at: https://www.iser.essex.ac.uk/euromod/resources-for-euromod-users/country-reports

individual/household characteristics and the returns to these characteristics (see (4)) We decompose the non-policy effect into changes in the following components: wages (without returns to university degree), returns to university degree expressed in wages, self-employment income, other market income (investment income, private pensions), employment status (hours bands, being self-employed, being unemployed), number of children (1, 2, 3 and more), level of education (secondary, college, undergrads, masters, PhD), region of where the household resides (12 regions), ethnic group (10 groups) and demographic characteristics (combination of sex, age and number of adults in the household).

Here is an example of how the decomposition of the non-policy effect is carried out. Assume we want to understand what the distribution of household disposable income in period 0 would be for the period 1 population. First, we estimate a log-hourly-wage model for period 0 and 1 separately. Second, we replace the estimated coefficients from period 1 with the ones from period 0. Third, we scale up the variance of the residual terms by the ratio of the estimated variance in period 0 to that of period 1. Fourth, we predict wages given population characteristics to that of period 1. The result would be an estimate of the wages of period 1 population if individuals were renumerated according to the returns from period 0. Fifth, we calculate the new household disposable income using the tax-benefit microsimulation model EUROMOD based on the newly estimated wages (and the tax and benefit policies as of period 0). The result would be the effect of changes to wages and the automatic stabilisation effect of the tax-benefit system on the household disposable income.

Formally, let us consider $\beta$ as hourly wages, $u$ as the returns to university degree (expressed in hourly wages), $s$ as self-employment income, $i$ as other market income (private pensions/ investment income/ housing expenditures), $a$ employment status, $n$ number of children in the household, $l$ level of education, $r$ region of residence, $g$ ethnic group and $d$ demographic characteristics. After accounting for the effects of all these components, there could be a change in the disposable income $e$ which remains unexplained. Hence, changes in market incomes and household characteristics $y$ can

\[ y \] 4\(^{(?)}\) extend the Oaxaca-Blinder decomposition of the mean to explain differences in the entire distribution of gross incomes. They decompose the difference in Gini between Brazil and the US into price (earnings) and endowment effects (education level, household structure, occupation).
be expressed as the function $f(\beta, u, s, i, a, n, l, r, g, d, e)$ and decomposed as

$$\Delta I_O = \frac{I[d_0(p_0, y_1)] - I[d_0(\alpha p_0, \alpha y_0)]}{\text{Non-policy effect conditional on policy and take-up 0}}$$

$$\Delta I_O = \frac{I[d_0(p_0, f(\beta_1, u_1, s_1, i_1, a_1, n_1, l_1, r_1, g_1, d_1, e_1))] - I[d_0(\alpha p_0, f(\beta_0, u_0, s_0, i_0, a_0, n_0, l_0, r_0, g_0, d_0, e_0))]}{\text{Non-policy effect conditional on policy and take-up 0}}$$

Wages

Reverting to university degree

Self-employment income

Other market incomes

Employment status

Number of children

Level of education

Region

Ethnicity

Demography

Unexplained part

In each of the steps we replace one component at a time and produce counterfactual distributions of household income and so, the differences in the value of $I$ gives us the associated change in $I$ with the change in one of the components. We derive the
counterfactual scenarios the following way.

First, to estimate the effect of changes in the returns to household characteristics, i.e. in terms of wages and other market incomes, we seek to estimate a set of parameters associated to the structure of returns in the labour markets and with the employment status of the individuals.

In both periods, we predict hourly wages based on a vector of characteristics, such as age (divided in bands of 5 years) interacted with level of education, number of hours in work (divided in bands), ethnicity, region of residence, number of children in the household, number of adults in the household, average age of the household, average number of years of schooling in the household, whether the person is the household head or not, and whether the person is in a couple or not. Two separate models are estimated for men and women. The wage equation looks in the following way (see (4)):

$$\ln y_i = \alpha + X_i\beta_i + \epsilon_i$$  \hspace{1cm} (4)

where $y_i$ is the logarithm of the individual hourly wage, $\alpha$ is the regression intercept, $X_i$ are individual or household level characteristics, $\beta_i$ represent the returns to these characteristics and $\epsilon_i$ the residual for person i. The residuals are predicted in scaling up the variance of the residual terms by the ratio of the estimated variance in period 0 to that of period 1.

For each of the other income/expenditures components, investment income, private pensions and housing expenditures, we use OLS regression. The covariates included in the regression are gender, age (divided in bands of 5 years) interacted with level of education, ethnicity, region of residence, number of children in the household, number of adults in the household, average age of the household, average number of years of schooling in the household, whether the person is the household head or not, and whether the person is in a couple or not.

As a next step, we model the employment status. It is presented by the following groups: working certain number of hours (0, 1-15, 16-29, 30-39, 40-49, 50+), being self-employed, or being unemployed. We model the employment status separately for men and women aged between 16 and 70. The employment status depends on a set of characteristics, such as age (divided in bands of 5 years), level of education, number of children in the household, number of adults in the household, average age of the household, average number of years of schooling, whether the person head or not, and whether the person is in a couple or not. We estimate the allocation of the individuals across the working hours groups through a multinomial logit model (see
\[ Pr\{j = s\} = Pr\{U^s = Z\lambda_s + \epsilon^U \geq U^k = Z\lambda_k + \epsilon^U, \forall k \neq s\} = \]
\[ P^s(Z_i, \lambda) = \frac{e^{Z_i\lambda_s}}{e^{Z_i\lambda_s} + \sum_{k \neq s} e^{Z_i\lambda_k}} \]

(5)

where we calculate the probability of an individual choosing employment status \( j \) over \( s \).

As next, we predict the number of children in each household separately for couples, lone mothers and lone fathers. The covariates we use are the ethnicity of the individual (the mother in the case of couples), age (divided in bands of 5 years) and level of education (and the same for the partner of the mother in the case of couples), and region of residence. The outcome variables is 0, 1, 2, 3+ for children in couples; 0, 1, 2, 3+ for children with lone mothers; and 0, 1, 2+ for children for lone fathers.

The level of education is predicted based on age (divided in bands of 5 years), ethnicity, whether the person is in a couple or not, region and gender. The outcome variable has values 1 (if only with secondary school degree), 2 (if with college degree), 3 (if with undergraduate degree), 4 (if with masters degree) and 5 (if with a PhD).

Each of the 12 regions of residence is estimated based on age (divided in bands of 5 years), the number of adults in the household and ethnicity.

Each of the 10 ethnic groups is estimated on age (divided in bands of 5 years) and number of adults in the household.

Number of children, level of education, region and ethnicity are modelled through a multinomial logit model.

Number of adults in the household (1, 2, 3+), sex and average age of the household members (divided in bands of 5 years) are modeled non-parametrically through re-weighting. Individuals are partitioned in groups depending on these characteristics. We use the methodology proposed in Gomulka (1992) to reweight survey data to specified control totals while minimising the distance between the new weights and the original weights.\(^5\) As a result of the re-weighting each household will be given a new weight to mimic the joint distribution of characteristics in the previous period.

The unexplained part is due to changes in the income distribution we do not model, e.g. changes in the distribution of private transfers, partnership formation/dissolution etc.

\(^5\)We use the user written command in Stata reweight2.
2.3 The automatic stabilisation effect of the tax-benefit system

The non-policy effect on household disposable income is derived by keeping the policies from a period 0 constant and only altering the characteristics of the individuals and households and the returns to these characteristics. Let us assume that we observe the returns to higher education to be falling over time. This will result in a counterfactual where individuals with higher education have lower wages and as a consequence, they might become eligible to certain income-tested benefits. That is, the tax-benefit system, although the same, will 'step in' to counterbalance the negative effect of wage drop. In the literature, this is referred to as the automatic stabilisation effect of the welfare state (see e.g. (?) and (?)). If we only look at the total change of disposable income, we will not be able to understand which part of the change is caused by changes in the returns to higher education, on the one hand, and the automatic stabilisation effect of the tax-benefit system, on the other. Thus, we decompose the non-policy effect by income sources, i.e. change in the indicator variable $I$ due to changes in gross market incomes vs changes in taxes and benefits.

2.4 The nominal effect

Finally, the nominal effect is the difference in disposable incomes due to the indexation factor $\alpha$. We define it to equal growth in prices (CPI). An indexation by CPI shows how tax thresholds and benefit amounts have grown relative to prices and yields whether families-on-benefits living standard have kept with the increase in prices. In regard to the non-policy effect, $\alpha$ will yield how market incomes have grown in real terms.

3 Data

The survey data that have been used for the analysis are from the Family Resources Survey (FRS) for 2001/02, 2007/08 and 2011/12. The data are cross-sectional, nationally-representative and contain rich information on households living conditions and the resources available to them. They include detailed information on socio-economic characteristics of individuals and households and different types of their incomes, e.g. market incomes, benefits, pensions and paid taxes. The main difference between FRS 2001/02 and the two later waves of the data is that the former does not include households from Northern Ireland in the sample. The methodology for deriving the household weights in FRS 2001/02 was revised in 2005 and matches

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6For more discussion on the implications of different indexation factors, see (?).
the methodology used in the later waves. FRS data are used by different government and non-government bodies, e.g. for analysing trends in the income distribution, poverty and inequality by the Institute for Fiscal Studies (IFS) and for analysing trends at the bottom of the income distribution by the Department for Work and Pensions (DWP).⁷

[Table 1 here]

4 Results

Figure 1 shows the total change in percent of the mean 2007 household disposable income across the 10 decile groups between 2001-07 and 2007-11. In both periods, households from all income decile groups have seen their incomes rising. Between 2001-07, the bottom decile groups saw their incomes increasing the most. The total change is decomposed into policy, take-up, non-policy effects and nominal effect equal to CPI.

Looking at the policy effect only (the green line), it has been progressive in both periods. In the first period, the first 3 income deciles have benefited the most (due to benefit increases), while the top 5 income deciles lost from policy changes (mostly changes to taxes). During the recession period, the policy effect lead to smaller income changes but it kept its progressive nature.

Based on the changes in the take-up assumptions, the take-up effect (darker gray line) lead to income losses for the bottom decile group between 2001-07, i.e. take-up fell. In the recession period, benefit take-up increased, leading to small but significant income increases for the poorest decile group.

The non-policy effect (the orange line) has been regressive in both periods leading to larger gains (in 2001-07)/smaller losses (in 2007-11) for the top decile groups relative to the bottom decile groups. But to understand better what the non-policy effect is a result of, we examine in detail figures 2-5.

[Figure 1 here]

Figure 2 decomposes the non-policy effect in 2001-07 into 11 separate components. Each one of them represents the effect of the changes in: the returns to people’s characteristics in terms of wages (without changes to the returns to university degree), returns to university degree in terms of wages, self-employment incomes, other market incomes, employment status, number of children, education

⁷For more information on FRS, visit: https://www.gov.uk/government/collections/family-resources-survey-2
level, region, ethnicity, demography and unexplained part. The components are ordered from 1 to 11 which reflects the decomposition order. As in Figure 1, the vertical axis displays the percent change of mean 2007 household disposable income while the horizontal axis shows the 10 decile groups. The orange line in all figures is the same equal to the 2001-07 non-policy effect. The blue lines display the change in disposable income due to changes in the separate components of the non-policy effect and they add up to the orange line.

There are three main messages to take up from this figure. First, changes in the returns to individual and household characteristics expressed in wages and expansion in higher education attainment (education level) have lead to income increases especially at the top of the income distribution resulting in increased income inequality. Second, changes in the returns to university degree (expressed in wages) have resulted in income losses at the top of the distribution and a small inequality reduction. Third, an increased internal migration (out of London to other parts of the country) together with increased returns to residing outside London have resulted in income increases, larger at the bottom of the distribution than at the top. However, these have been almost entirely offset by the negative effects of increased immigration (mostly from Eastern Europe) in this period.

[Figure 2 here]

It is important to note that these results refer to changes in household disposable income which is the sum of changes to market incomes and taxes and benefits. Although in the decomposition of the non-policy effect the tax-benefit policies are kept constant as of 2001, they react to the changes in market incomes (wages, self-employment etc.) as well as to the changes in people’s characteristics which we observe in the different counterfactual scenarios. This response, as referred to in the literature, is called automatic stabilisation effect. Figure 3 builds on Figure 2 by decomposing the change in household disposable income into the changes in market incomes (pink bars) and the automatic stabilisation effect (blue bars) of 2001 policies. The bars add up to the blue lines in each figure. We can interpret the results in the following way. Let us take the graph representing the effect of changes to wages on household disposable income. We can see that the increase in wages (pink bars) has been partially offset by the automatic increase in the income tax liability (blue bars). If we look at the graph displaying the changes in ethnicity, the automatic stabilisation effect of 2001 policies contributes to income losses for the poorest income decile. This is due to changes in the characteristics of the population - the new migrants tend to be young singles or couples without children which automatically removes their entitlement to means-tested benefits containing
a child component. The drop in market incomes (mainly wages) along the rest of the distribution is associated to the falling returns to not being White British and has been somewhat offset by the automatic reduction in the income tax liability.

The main message to take from Figure 5 is that the non-policy effect would have been even more regressive if it was not for the tax-benefit system. The direct policy effect together with the automatic stabilisation effect stress the important role of the tax-benefit system in reducing income inequality - a role so far understated by the previous literature focusing only on the policy effect.

[Figure 3 here]

Figure 4 and Figure 5 show results for the crisis period. In 2007-11, due to real drop in wages households across the entire distribution have seen their disposable incomes falling. Interestingly, there were no changes to the returns to university degree (expressed in wages) which remained resilient. Expansion to higher education attainment continued to contribute to income increases at the top of the distribution even during the crisis. Furthermore, we continue observing the gains from internal migration being neutralised by the losses from immigration. Similarly to Figure 3, Figure 5 shows that the automatic stabilisation effect of the 2007 policies reduce the inequality increase by the non-policy effect.

[Figure 4 here]

[Figure 5 here]

5 Conclusions

This paper decomposes changes in the entire distribution of household disposable income in the UK in the period between 2001 and 2011. It combines the use of the tax-benefit microsimulation model EUROMOD with parametric and non-parametric methods. The changes in the income distribution are attributed to direct policy changes, changes to benefit take-up, and changes to population’s characteristics and the returns to these characteristics. We focus on the non-policy effect and provide insights about the degree to which different factors have affected households incomes. The decomposition of the non-policy effect into changes in market incomes and the automatic stabilisation effect of tax-benefit policies provides novel evidence on the importance of the tax-benefit system in reducing income inequality.
References


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6 Tables and Figures
Table 1: Data description

<table>
<thead>
<tr>
<th>Input dataset</th>
<th>N households</th>
<th>N individuals</th>
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<tbody>
<tr>
<td>FRS 2001/02</td>
<td>25,320</td>
<td>59,499</td>
</tr>
<tr>
<td>FRS 2007/08</td>
<td>24,977</td>
<td>56,926</td>
</tr>
<tr>
<td>FRS 2011/12</td>
<td>20,759</td>
<td>47,744</td>
</tr>
</tbody>
</table>

Figure 1: Decomposing the total change in hh disposable income in 2001-11

Note: The orange, green and gray lines add up to the black line
Figure 2: Decomposing the non-policy effect on hh disposable income in 2001-07

Note: The orange line is the same in all figures. The blue lines add up to the orange line. The figures are numbered according to the decomposition order.
Figure 3: Decomposing the non-policy effect on hh disposable income in 2001-07

Note: The orange line is the same in all figures. The blue lines add up to the orange line. The bars add up to the blue lines. The figures are numbered according to the decomposition order.
Figure 4: Decomposing the non-policy effect on hh disposable income in 2007-11

Note: The orange line is the same in all figures. The blue lines add up to the orange line. The figures are numbered according to the decomposition order.
Figure 5: Decomposing the non-policy effect on hh disposable income in 2007-11

Note: The orange line is the same in all figures. The blue lines add up to the orange line. The bars add up to the blue lines. The figures are numbered according to the decomposition order.