

FISCAL POLICY, GROWTH AND INCOME DISTRIBUTION IN UK

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January 5, 2012

Abstract

The UK economy growing annually at 2.05 percent and leading the world between 1750 and 1850 experienced a sharp rise in income inequality at the high point of the industrial revolution. A series of tax and transfer enactments from the parliament to protect workers and low income households started towards the end of the nineteenth century reversed this trend making Britain one of the most egalitarian economy in the world by 1960s. New wave of reforms in tax-transfer system and the markets in the last forty years aimed at higher economic growth have raised inequality again both in the original and the post tax income causing widespread concerns. Solutions of the multi- household, multi-sectoral dynamic general equilibrium model show that fiscal policy measures impact on growth paths, capital accumulation and investment processes across sectors and in the distribution of income among households. Greater equality does not automatically guarantee greater welfare when the economy is not growing. By taking account of the intertemporal income and substitution effects this model can provide more accurate analysis of impacts of fiscal policy measures on the labour-leisure and consumption decisions of households and input choices of firms. Such analysis is helpful in setting a long-term optimal policy measures based on structural realities to maintain a balance between growth and equity in the 21st century.

Keywords: growth, redistribution, fiscal policy, UK

JEL classifications: D5, E6, O4, O55

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1 Introduction

The annual average growth rate of GDP in the UK was 0.2 percent on average (0.08 percent in per capita) between AD 1 and 1830 and 2.05 percent (1.5 percent in per capita) between the years 1830 and 2008 (Fig. 1 and 2)¹. Recessionary episodes were frequent but dynamic forces of growth eventually pulled the economy into its long term growth path. Hansen and Prescott (2002) illustrate how the Malthusian model with the labour and fixed land inputs in production function fitted well to the English economy from 1250 to 1800 and the Solow model with the constant returns to scale in production with labour, capital and technology from 1800 to 1989. Kuznets (1955) had found widening of income inequality in England in the early phases of industrialization between 1780 and 1850, when the transition from the mercantilist state to the industrial civilisation was most rapid. The process of urbanisation, lower death rate and higher birth rate, rising rate of saving, investment, capital accumulation and profit contributed to such inequality that remained high till 1875. Share of top five percent income group fell from 46 percent in 1880 to 24 in 1947 while that of bottom 85 percent increased from 41 percent to 55 percent in the same period as a result of several entitlement laws (Finance Acts) enacted by the UK parliament to move towards a more egalitarian tax and transfer system (Bowley 1914) creating a tax-wedge between the original and post-tax income.

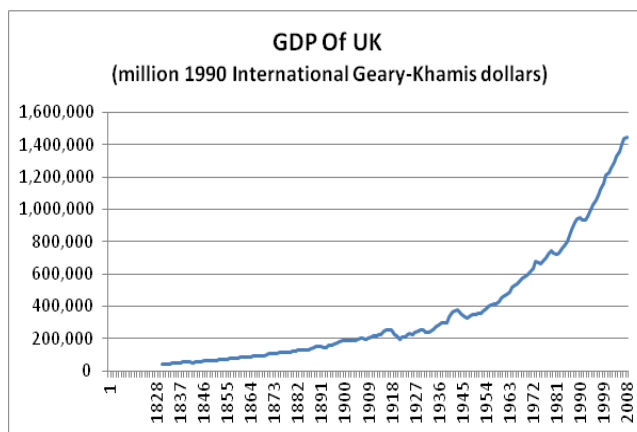


Fig. 1

¹Based on data provided by Maddison (1991) at <http://www.ggdc.net/maddison/>. See also Parente and Prescott (2002).

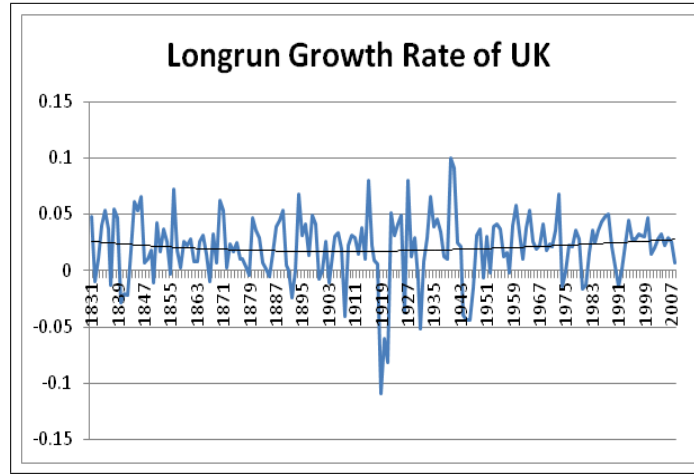


Fig. 2

The public finance in UK, until 1815, was limited to heavy borrowing to finance military and naval expenses during the wars and redeeming such debts using revenues from rents, royalties and indirect taxes in the peaceful years (O'Brien (1988), Fig. 4). Equity issues were ignored in the traditional feudalistic or mercantilist mind-set of 'the rich man in his castle, the poor man at his gate, God made them high and lowly and ordered their estate' even after the Magna Carta (1215) and the Glorious Revolution (1688) that had transferred political power to the people and the parliament. According to economic historians the unprecedented economic growth brought by the industrial revolution and development of trade, commerce and capitalism not only made UK a global economic leader from 1750 to 1850 but also created wide gaps in the distribution of income and wealth between the rich and the poor (Williamson (1980), Ward(1994), Weaver 1950). In celebrated four cannons of taxation Smith (1776) preached for equality, certainty, convenience and economy while taxing rents, wages and profits. He was worried more on efficiency rather than on redistribution. Frustrated by the plight and worsening living conditions of workers, socialist reformers and radical thinkers including Wilberforce, Owen, Marx and Engels supported unions to organise and agitate for more equal rights and better working conditions of workers. This movement raised the number of MPs representing workers such as Snowden (1907), who eventually were able to promulgate a series of entitlements by enshrining them into the laws such as the Income Tax Act (1853) or Finance Act (1909). Clauses to mobilise additional revenues from the direct and indirect taxes to provide for social services including education and health that followed truly initiated an egalitarian tax and transfer system raising the size of state in the economy to 10 to 12 percent of the national income (Fig 3).

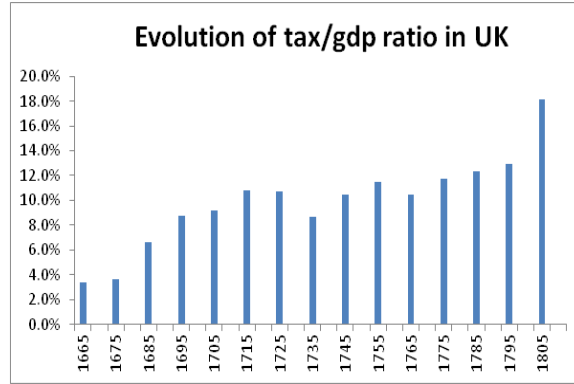


Fig. 3

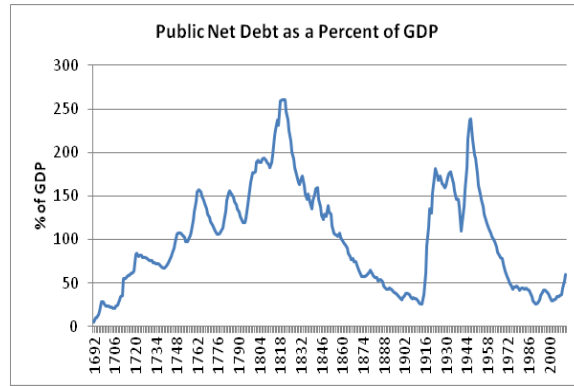


Fig. 4

A massive expansion in the public sector relative to the GDP that occurred through the public debt during the World Wars I and II, as suggested by Keynes (1940), left a legacy of a large public sector that have become a permanent feature of the UK economy since then (Hicks, 1954). Acts aimed at relieving the war devastated economy resulted in the public commitment to the social security system as proposed in the Beveridge report in 1942 brought the share of public sector to around 40 percent of GDP as shown in Table 1. While it seems obvious that the public tax and transfer system has eliminated absolute poverty among the bottom income group, inequality of income has widened further after the another wave of reforms of the public finance that started in early 1980s. It is shown by increase in Gini coefficients of both the original and post tax income from 28.6 in 1970s to 38.3 in 2000s in Table 1. High inflation has further made distribution of income more unequal as the burden of higher inflation are born mostly by the low income households (Keynes 1940, Sargent 1987). Such an upward trend in the inequality in the last two decades despite a continuous reform of the tax and benefit are discussed in greater details in Dutta, Sefton and Weale (2001), Johnson and Webb (1993) and Clark and Leicester (2004) for the UK and Aghion et al. (1999) for other countries.

Table 1: Fiscal policy, growth and inequality in the UK: Recent Trends

	1950s	1960s	1970s	1980s	1990s	2000s
Revenue/GDP	41.1	40.0	41.1	42.5	37.1	37.3
Spending/GDP	39.0	40.2	44.4	44.7	40.4	40.7
Deficit/GDP	2.0	-0.2	-3.3	-2.2	-3.3	-3.4
Debt GDP ratio	145.0	89.6	49.9	40.6	34.6	34.2
Growth rate	2.5	3.1	2.4	2.5	2.2	1.7
Gini of original income	41.3	32.1	43.3	48.8	52.4	51.7
Gini of post tax income	35.4	25.1	28.6	33.8	38.6	38.3
Inflation	4.2	3.6	13.6	7.6	3.6	2.5
Data source: ONS, OBR, IFS, and http://www.ukpublicspending.co.uk/index.php Gini for 1950 and 1960 rely on Stark (1972), Barna (1945), Nicholson (1964).						

Despite above U-shaped trend in inequality one still finds a significant degree of redistribution taking place in the UK under the existing tax-benefit system. Net of tax income of the top income households are trimmed down and that of bottom income group is raised substantially by it. For instance in 2009, as shown in Table 2, the net tax payment by an average top 20 percent income earner raises enough revenue to finance benefits received by an average bottom 40 percent household, who get around net amount of ten thousand pounds each, twice as much as their contribution to the Treasury (Fig. 5). The extent of redistribution is less serious in the middle income group where 4 thousand pounds received by the 3rd quintile almost matches the net tax payment by the fourth quintile (Table 2). In real income terms the impacts of redistribution are more pronounced for households in the top and bottom income groups. The absolute amount received in benefits or paid in taxes grow with the growth of the economy.

Table 2: Net Effects of Tax and Transfer to an Average Household by Quintile in 2009

	Benefits			Taxes			Net
	Cash	In Kind	Total	Direct	Indirect	Total	Gain or Loss
Bottom	6883	7555	14,438	-1195	-2965	-4,160	10,278
2nd	8280	7252	15,535	-2200	-3466	-5,666	9,866
3rd	6139	7088	13,227	-4850	-4459	-9,309	3,918
4th	3949	6162	10,111	-8403	-5386	-13,789	-3,678
Top	1992	5123	7,115	-19500	-7441	-26,941	-19,826
Average	5448	6636	12,084	-7230	-4743	-11,973	111
Data source: Office of the National Statistics; in £.							

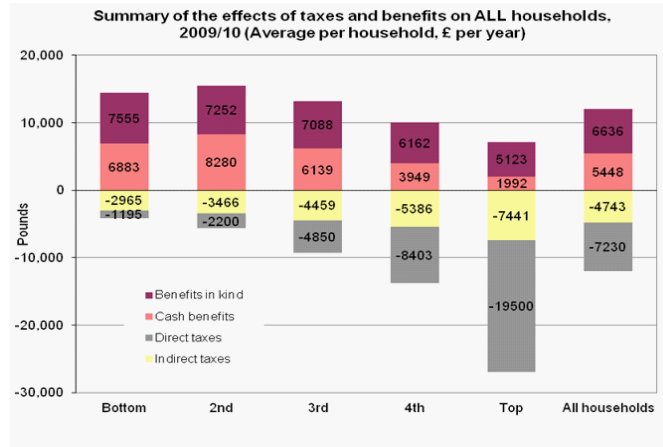


Fig. 5

Time series on a sets of income measures including the original, gross and post-tax income, available from the Office of the National Statistics (<http://www.ons.gov.uk/ons/statbase/>) are helpful in estimating the impacts of tax and transfer in income of a household by the decile or quintile they belong to. The original income contains the sum of wages and salaries, interest and profit, annuities and pension, investment and other income. The gross income is obtained by adding cash benefits, total of contributory and non-contributory types, to the original income. Direct taxes - income tax, national insurance and council tax, are deducted from the gross income to calculate the disposable income. Further deductions of indirect taxes from it results in the post tax income (PTI) which truly measures the real economic position of a household as in Table 3 for each decile. In kind benefits including education, health and housing subsidies are then added to get the amount of final income. Thus comparing inequality in the original and PTI provides a rough indication of the difference made by the tax and transfer system in the distribution of income among households in UK (Blundell 2001, Bhattacharai, and Whalley 2009). As expected the post-tax income is less unequal than the original income; compare 4.0 versus 69.6 thousands of PTI to 1.9 versus 101.5 thousands of original income in Table 3 for the bottom and top income household respectively.

Source: Constructed from data available at: <http://www.statistics.gov.uk/STATBASE/Product.asp?vlnk=10336>;

Table 14A.

A summary of redistribution by taxes and transfers by quintile is given in Table 4. While the average share of the bottom quintile was about 2.5 percent of original income in comparison to 50.7 percent of the top quintile, the operation of the tax and transfer system lifts the share of the bottom quintile up to 6.8 percent in the PTI and drops the share of top quintile down to 43.8 percent of it. These shares have fallen for the bottom groups and risen for the top groups in the last two decades as is clear from the smaller area under the Lorenz curve in 1983 compared to that in 2009 in Fig. 6.

Table 3: Pattern of Income Distribution in 2009 (in '000 Pounds)

	Bottom	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	All
Households (in mln)	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	26
Original income	1.9	4.2	7.3	11.7	18.0	24.	33.5	43.3	58.5	101.5	30.5
Cash benefits	4.9	7.0	7.6	7.5	6.2	5.2	4.2	3.2	2.3	2.4	5.0
Gross income	6.8	11.2	15.0	19.2	24.2	30.1	37.7	46.6	60.8	103.9	35.3
Direct taxes	0.8	1.1	1.8	2.7	4.0	5.4	7.6	9.9	14.0	24.7	7.2
Disposable income	6.0	10.1	13.1	16.5	20.2	24.7	30.1	36.7	46.8	79.2	28.4
Indirect taxes	2.0	2.2	2.7	3.3	4.2	4.6	5.4	6.3	7.2	9.6	4.7
Post-tax income	4.0	7.9	10.4	13.2	16.1	20.1	24.8	30.4	39.6	69.6	23.6
Inkind benefits	3.5	4.0	4.8	5.7	5.7	5.7	6.4	6.6	6.1	6.7	5.5
Final income	7.6	11.8	15.2	18.9	21.8	25.8	31.2	37.1	45.7	76.3	29.1

Table 4: Share of origina and post tax income by quintile in UK, 2009

	Original income share	Post-tax income share	Impacts of tax and transfers, %
Bottom	2.46	6.75	4.29
2nd	6.92	11.33	4.41
3rd	15.04	15.92	0.88
4th	24.92	22.25	-2.67
Top	50.71	43.75	-6.96

Data source: Office of the National Statistics

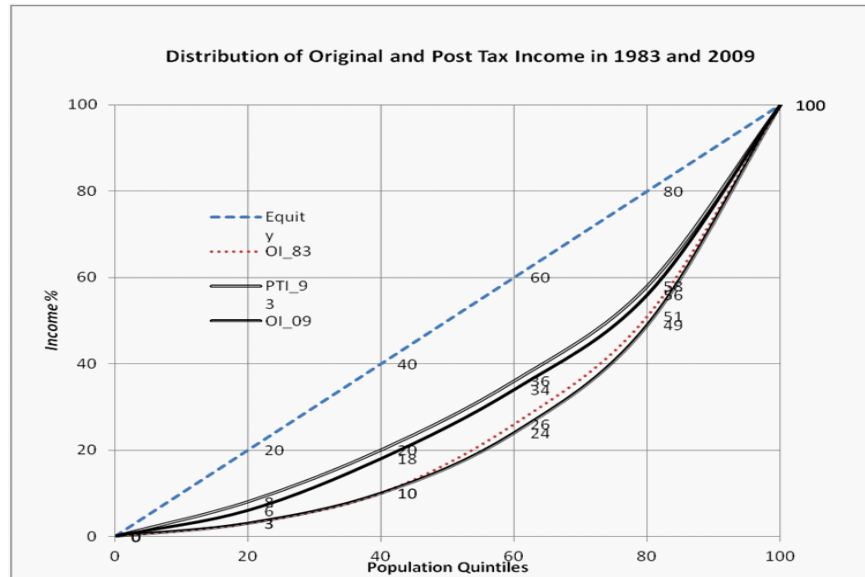


Fig. 6

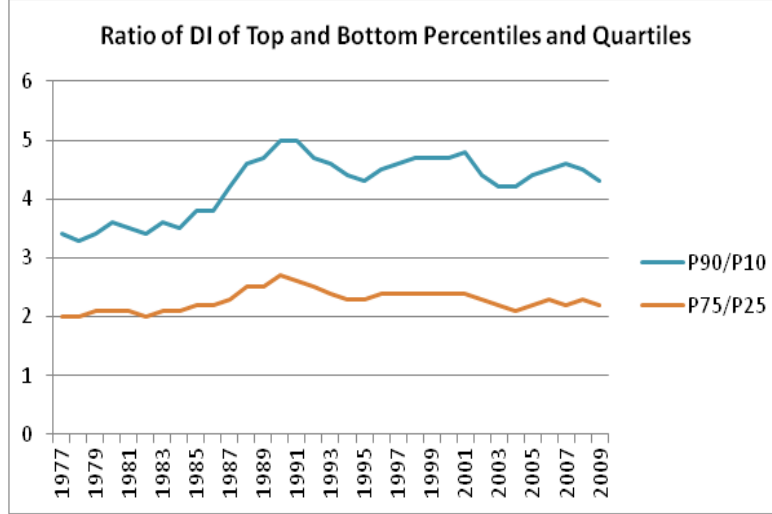


Fig. 7

The ratio of disposable income of 90th to 10th percentile was around 4.5 twice as much to the ratio of the 3rd to the first quartile.

1.1 Middle income hypothesis

It is a common perception in the UK that workers in the middle income group drive the economy, they generate the value that is distributed to idle rich and needy poor households. In this so called middle income-group hypothesis the growth rate of the economy depends on the relative share of this group. Support for this hypothesis is found in the data as indicated by significant coefficients on the share of post tax income of the third quintile (3rd_PTI) and that of the fourth quintile (4th_PTI) in the growth equation. In contrast a higher growth rate does not raise inequality as coefficient on growth is not statistically significant in the inequality equation. Inequality (Gini coefficient) falls only by raising the share of bottom income group (see also Beaudry et al. 2009).

Table 5: Growth Inequality Relations: Testing Middle Income Share Hypothesis

Change in growth rate on quintile shares				Inequality (Gini-all) on growth rate			
Variables	Coefficient	t-value	t-prob	Variables	Coefficient	t-value	t-prob
Intercept	0.54**	21.0	0.00	Intercept	44.6**	16.1	0.00
3rd_PTI	1.81*	2.3	0.03	Growth	-0.29	-1.7	0.10
4th_PTI	-1.32	-2.6	0.02	Bottom_PTI	-1.48**	-3.6	0.00
R ² = 0.41, F(1,21) = 7.04 [0.00]** χ ² =8.77(0.02) DW=1.11, N=24				R ² = 0.45, F(1,21) = 8.9 [0.02]* χ ² =1.5(0.47) DW=1.94, N=24			

While the fairness of tax system was at the heart of Meade (1951, 1978) as the optimality of taxes were in Mirrlees (1971 and 2011) the reversion of the

Kuznets process as indicated by above in the UK in recent years (Gemmell 1985, Atkinson and Voitchovsky 2011) clearly show that those ideas have not been translated into actions adequately. Behavioural responses to welfare system are shaped fundamentally by the structural features of the economy including the preferences of households, technologies and composition of firms or the trading arrangements with the global economy. Proper evaluation of full impacts of tax transfer policies therefore requires an applied dynamic general equilibrium model that takes account of the decentralised structure of the UK economy. Even though the general equilibrium model have been built for the UK to study intersectoral and multi-household allocation issues since the pioneering work of Whalley (1975, 1977) and then in Piggott and Whalley (1985) only limited efforts have been made to measure the dynamic impacts of taxes in efficiency and growth simultaneously (Bhattarai 1999, 2007). In the current context of rising inequality and declining growth rate, what will happen to these in the next century is an issue of immense interest which we aim to analyse in this paper.

1.2 Current Fiscal Policy Context

As the recovery from the 2008-09 recession towards the steady state has been very slow the current fiscal policy of UK aims at achieving the macroeconomic stability, supporting the pro-business and low carbon growth, achieving fairness and providing opportunities for all and in protecting the public services. The programmes and activities that the government can implement to achieve these are limited, however, by its intertemporal budget constraints. A careful analysis of the ratios of revenues, spending and deficit to the GDP in Table 6 (and Fig. 8) shed some lights on this. Current forecasts of spending targets, revenues and public deficit are set in the context of slow recovery after the recession that lasted for seven quarters from the second quarter of 2008 to the 4th quarter of 2009. Expansionary fiscal and monetary policies taken by the government and the Bank of England have taken economy out of the slump but these are projected to raise the debt ratio to 78 percent of GDP by 2015 and exerting an inflationary (stagflationary) pressure in the economy (OBR and HM-Treasury, 2011). While these short run policy measures were taken to stimulate the economy so that it could return to its long run equilibrium path, what will happen in the next 80 years from such short run policy measures are determined more by the broad parameters that guide choices of households, firms and traders in the economy. While there is a pressure on the government to stick to the Smith's cannons of taxations as stated above it faces further challenges in incorporating ability to pay and benefits to tax payers from public spending principles that Mirrlees (1971, 2011) and Meade (1978) have proposed for the UK in recent years. While these studies provide hints for the computations or estimation of the excess burden of taxes in the context of current economic climate, proper quantification of the economic effects policies on equity, efficiency in allocation, growth and sectoral composition of output and employment over time is a task that can be done only with a more elaborate dynamic general equilibrium model of the UK

economy.

Table 6: Ratios of Revenue, Spending and Deficit to GDP (OBR)

	2016	2015	2011	2010	2009
Revenue/GDP	37.8	37.7	37.8	37.3	36.5
Spending/GDP	39.0	40.5	46.2	46.6	47.7
Deficit/GDP	1.2	2.9	8.4	9.3	11.1
Debt/GDP	75.8	77.7	67.5	60.5	52.8

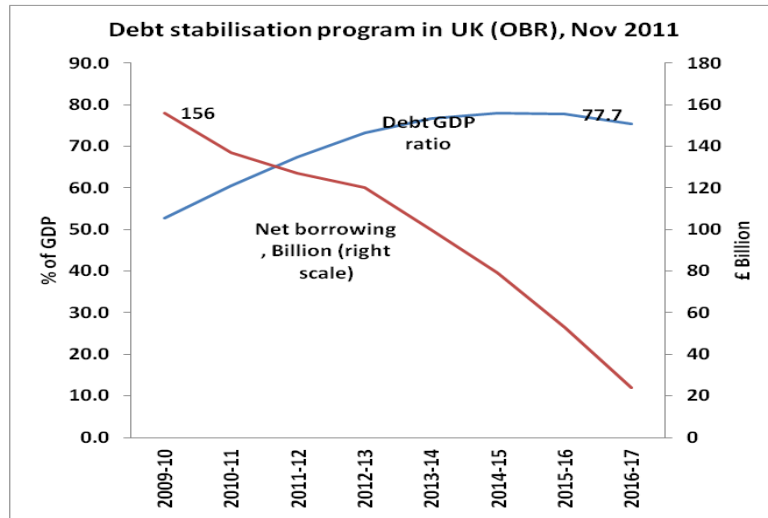


Fig. 8

The UK government has set its activities within the constraints set by the structure of revenue and spending that have evolved over years. By striking a balance between the direct taxes (income tax, national insurance, corporate tax and council tax) that bring about 60 percent of total revenue and the indirect taxes (VAT/Excise and Business Rates) for the remaining 40 percent to minimise the burden of taxes (Table 7). This requires assessment of the more complicated economy-wide income and substitution effects which depend on the flexibility of markets as reflected in the elasticities of demand and supplies of goods and factors of production over time (Whalley 1975, Bhattacharai and Whalley 1999). While the right blending of progressive income and corporation taxes with regressive national insurance contribution, council taxes and VAT, petrol and fuel duties, business and other taxes is necessary to minimise the burden of taxes, the actual post tax distribution is determined not only by the net of tax income but also by the allocation of public provision of various items of public services and accessibility of households to them. As Table 8 shows around 60 percent of the public spending takes the form of transfer of resources mainly

from high income to low income individuals or families for social protection, for personal social services, for health, education and transport services and the remaining 40 percent provides for the basic public goods including defence, public order and safety and servicing of debt required for the smooth functioning of the economy. Thus it is important to consider both the revenue and spending sides simultaneously to assess impacts of fiscal policy on growth and redistribution.

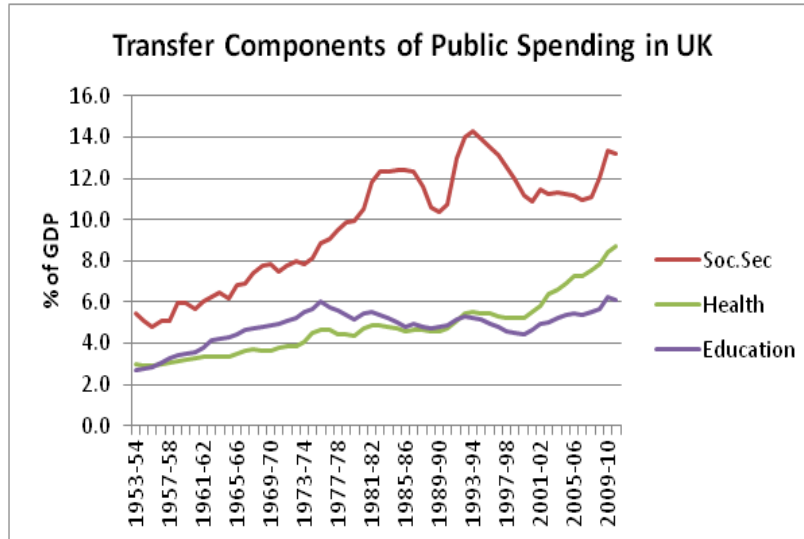


Fig. 9

Table 7: Source of Revenue in UK (GBP Billion)

Sources of Revenue	2011		2010		2009	
	Revenue	Percent	Revenue	Percent	Revenue	Percent
Income tax	158	0.27	150	0.27	146	0.27
National insurance	101	0.17	99	0.18	97	0.18
Corporation tax	48	0.08	43	0.08	42	0.08
Excise tax	46	0.08	46	0.08	46	0.09
VAT	100	0.17	81	0.15	78	0.14
Business tax	25	0.04	25	0.05	25	0.05
Council tax	26	0.04	25	0.05	26	0.05
Other	85	0.14	79	0.14	81	0.15
Total	589	1.00	548	1.00	541	1.00
Source: Budget Report (March 2011) HM Treasury, http://www.hm-treasury.gov .						

Note: In 2010/11 income tax is paid for any income above £7475 at the basic rate of 20% up to income of £35,000, at 40% rate on additional income up to £150,000 and at 50% for income above this. National insurance contribution

rate is 12% for every employee. Council tax rate vary by the value of property in A to H bands, A paying two third and H paying twice of band D which is liable for council tax amount of £1332 for each year. VAT is 20 % and corporation tax is 28 % of corporate profit, excise and business tax-subsidy rates vary by product, going up to 95 percent.

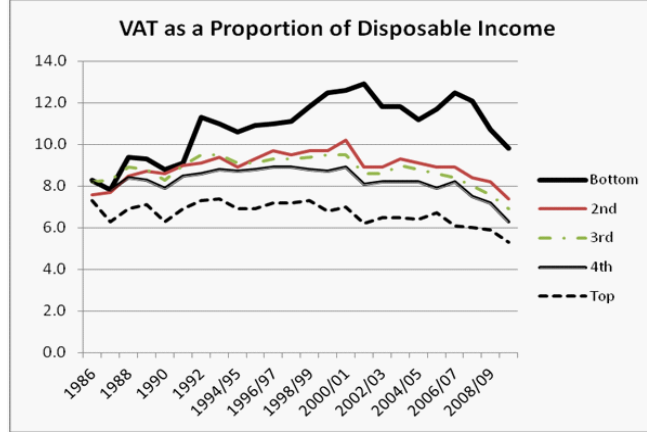


Fig. 10

Table 8: Elements of Public Expenditure in UK (GBP Billion)

Expenditure Items	2011		2010		2009	
	Spending	Percent	Spending	Percent	Spending	Percent
Social protection	200	0.28	194	0.28	190	0.28
Personal social services	32	0.05	32	0.04	29	0.04
Health	126	0.18	122	0.18	119	0.18
Education	89	0.13	89	0.13	88	0.13
Transport	23	0.03	22	0.03	23	0.03
Defence	40	0.06	40	0.06	38	0.05
Industry, Agr, Employment	20	0.03	20	0.03	21	0.03
Housing and Environment	24	0.03	27	0.04	30	0.04
Public order and safety	33	0.05	35	0.04	36	0.05
Debt and interest	50	0.07	44	0.11	43	0.06
Others	74	0.10	73	0.10	74	0.11
Total	711	1.00	696	1.00	704	1.00
Source: Budget Report (March 2011) HM Treasury, http://www.hm-treasury.gov .						

Above objectives and constraints faced by the UK economy can be successfully studied here with an applied dynamic general equilibrium model benchmarked to the micro-consistent data constructed from the latest input-output table for the decentralised market of the UK. Long run impacts of current policies on capital accumulation, investment, output and distribution among households is evaluated using results of this model for the 21st century (see Hansen

and Prescott (2002) applied Malthus model to 1275 to 1800 and Solow model to 1800-1989 for the UK). A multi-sectoral dynamic general equilibrium model calibrated to the micro-structural features provided by the input-output table and social accounting matrix of the economy is the most appropriate tool to assess long run impacts of fiscal policy in the economy.

2 Features of Dynamic Tax Model of UK

A general equilibrium model in spirit of Walras (1874), Hicks (1939), Arrow and Debreu (1954), Scarf (1973) and Whalley (1975) is a complete specification of the price system in which prices and quantities are determined for each year by the interactions of demand and supply sides of goods and factor markets. In the dynamic version the relative price for every good for each year depends on the intertemporal preferences of households regarding labour-leisure and consumption and of firms for capital and labour inputs similar to that in Ramsey (1927, 1928), Solow (1956) or Lucas (1988). Government influences market outcome by distorting the prices by means of taxes and transfers which impact on income, savings, investments and the growth rate of the economy and its production sectors. As a regular macro model, households, firms and traders optimise (Samuelson 1947, Sargent 1987, Prescott 2002) and choose optimal levels of labour supply, employment, consumption, production and trade. Intertemporal optimisation results in the optimal growth rate of output, capital and investment as in Holland and Scott (1998) or Jensen and Rutherford (2002). How can a set of policies be more efficient in terms of welfare to one household rather than to another is evaluated with a social welfare function. Model is good for analysing available alternatives for long run growth prospects from the accumulation of physical and human capital or for evaluating the efficiency gains from inter-temporally balanced budget or from the tax-transfer system or welfare reforms or from the low-carbon growth strategy. Short run fluctuations often studied in the Keynesian or the new Keynesian type economy could be introduced incorporating stochastic shocks to the production or the consumption sides of the economy (see Stern 1992 for desirable properties of this type of model). Dynamics of the applied general equilibrium model of UK with tax and transfer system contained here is an advancement on the comparative static frameworks available in the pioneering work of Whalley (1975), Piggott and Whalley (1985) and Bhattarai and Whalley (2000). This model is better suited to study growth and inequality and shows the evolution of the whole economy based on intertemporal optimisation problems of households, firms and the government for the 21st century.

2.1 Preferences

Model adopts a standard Ramsey (1928) type time separable constant elasticity of substitution (CES) utility function to measure the welfare of households in each period. They engage in the intra-period and inter-temporal substitution

between consumption and leisure on relative prices, interest rate, wage rate, tax rates and spending allocations in the economy. It contains AIDS demand similar to that in Deaton and Muellbauer (1980) and has multiple nests. The first stage of it is the aggregation at the level of goods and services ($C_{i,t}^h$), next stage of the nest is the choice between that composite goods and leisure (C_t^h, l_t^h) and finally choice is over consumption-saving decisions across various periods based on Euler conditions. Thus the problem of household h is:

$$\max U_0^h = \sum_{t=0}^{\infty} \beta^{t,h} U_t^h (C_t^h, l_t^h) \quad (1)$$

Subject to an intertemporal budget constraint of the form:

$$\left[\sum_{t=0}^{\infty} P_{i,t} (1 + tc_i^h) C_{i,t}^h + w_{j,t} (1 - tw_i^h) l_{i,t}^h \right] \leq \left[\sum_{t=0}^{\infty} w_{i,t}^h (1 - tw_i^h) \bar{L}_{i,t}^h + r_{j,t} (1 - tk_i) K_{i,t}^h \right] \quad (2)$$

here tax rates on consumption and income (tc_i^h, tw_i^h, tk_i) are set by the policy makers who aim for optimality and revenue neutrality in process of tax reform.

2.2 Production Technology

Each firm in the model has a unit profit function ($\Pi_{i,t}$) which is the difference between aggregate composite market price - the composite of prices of domestic sales ($PD_{i,t}$) and exports ($PE_{i,t}$), and prices of primary inputs ($PY_{i,t}$) and intermediate inputs ($P_{i,t}$). Thus the problem of a firm i is:

$$\max \Pi_{i,t} = \left((1 - \psi_i) PD_{i,t}^{\frac{\sigma_y - 1}{\sigma_y}} + \psi_i PE_{i,t}^{\frac{\sigma_y - 1}{\sigma_y}} \right)^{\frac{1}{\sigma_y - 1}} - \theta_i PY_{i,t} - \theta_i^d \sum_{t=0}^{\infty} a_{i,t} P_{i,t} \quad (3)$$

Subject to production technology:

$$Y_{j,t} = \left[(1 - \delta_i) K_{i,t}^{\frac{\sigma_p - 1}{\sigma_p}} + \delta_i L_{i,t}^{\frac{\sigma_p - 1}{\sigma_p}} \right]^{\frac{1}{\frac{\sigma_p - 1}{\sigma_p}}} \quad (4)$$

Sector specific capital ($K_{i,t}$) accumulation:

$$I_{i,t} = K_{i,t} - (1 - \delta) K_{i,t-1} \quad (5)$$

Here ψ_i and θ_i are share parameters, σ_y and σ_p are elasticities of substitution in trade and production, $a_{i,t}$ are the input-output coefficients giving the economy wide forward and backward linkages.

The real returns ($r_{j,t}$) from investments across sectors are determined by the marginal productivity of capital that adjust until the net of business tax returns are equal across sectors. The nominal interest rates set by the central bank should converge to these real rates in the long run. Wage rate of household h , w_t^h , equals its marginal productivity (Becker et al. 1990, Meyer and Rosenbaum 2001).

2.3 Trade arrangements

Economy is open for the trade. Domestic firms supply products differentiated from corresponding foreign goods. Traders decide on how much to buy ($D_{i,t}$) in the domestic markets and how much to import ($M_{i,t}$) while supplying goods ($A_{i,t}$) to the economy. Choice of consumers between imports and domestic consumption depend on the elasticity of substitution (σ_m) between domestic supplies and imported commodities in line of Krugman (1980) and Armington (1969). UK exports products that she produces at lower cost and imports products in which she has no comparative advantage.

$$A_{i,t} = \left(\delta_i^d D_{i,t}^{\frac{\sigma_m-1}{\sigma_m}} + \delta_i^m M_{i,t}^{\frac{\sigma_m-1}{\sigma_m}} \right)^{\frac{\sigma_m}{\sigma_m-1}} \quad (6)$$

$$\sum_{t=0}^{\infty} P E_{i,t} E_{i,t} = \sum_{t=0}^{\infty} P M_{i,t} M_{i,t} \quad (7)$$

UK economy, being one of the most liberal economies in the world, has almost no tax on exports and has very minimal tariffs and non-tariff barriers on imports.

2.4 Government sector

Government receives revenues from direct and indirect taxes and tariffs. These taxes are distortionary and affect the marginal conditions of allocation in consumption, production and trade causing widespread shifts in the demand and supply functions of commodities. Which ones of these tax instruments are optimal sources of revenue and which ones are the most inefficient for it and in generating growth process of the economy is a very important question but could be set following the logic of micro level incentive compatible mechanism of Mirrlees (1971, 2011) or in Diamond-Mirrlees (1971). It can adopt a balanced budget or a deficit budget or a cyclically balanced budget or inter temporally balanced budget or it may simply peg deficit to a fixed debt/GDP ratio. Which one of these strategies is adopted may depend on circumstances of the economy, policy debates and rules based on conventions and international commitments made in the treaties or agreements (i.e. EU or G20).

$$R_t = \sum_{h=1}^H \sum_{i=1}^N t c_i^h P_{i,t} C_{i,t}^h + \sum_{h=1}^H \sum_{i=1}^N t w_i^h w_{j,t}^h L S_{i,t}^h + \sum_{i=1}^N t k_i r_i K_{i,t} \leq G_t \quad (8)$$

Ideally people's preference for public good should decide the degree of freedom the government is given in determining the size public sector relative to the aggregate economic activities (Devereux and Love 1995, Barro (1990), Jensen and Rutherford (2002)).

2.5 General Equilibrium in a Growing Economy

General equilibrium is a point of rest, where the opposing forces of demand and supply balance across all markets in each period and over the entire model horizon. It is given by the system of prices of commodities and services, wage rate and interest rate in which demand and supply balance for each period (Hicks 1939). When a model is properly calibrated to the benchmark micro-consistent data set, such prices reflect the scarcity for those goods in the economy. Cost benefit analysis or economic decisions can be based on real level of welfare for a set of alternatives available to the households, firms and the government. Theoretically there has been much work, since the time of Walras, in finding whether such equilibrium exists, or is unique or is stable (Scarf 1973, Feenberg and Poterba 2000, Feldstein 1985, Friedman 1962, Lee and Gordon 2005, Hines and Summers 2009, Naito 2006, Lockwood and Manning 1993, Bovenberg and Sørensen 2009). Uniqueness is guaranteed by the properties of preferences, technology and trade, such as continuity, concavity or convexity or twice differentiability of functions. Explicit analytical solutions are possible only for very small scale models that are instructive but hardly representative of the economy (Heckman, Lochner and Taber 1998, García-Peñalosa and Turnovsky 2007). It is common to apply numerical methods to find the solutions of these models for a realistic policy analysis.

$$Y_{i,t} = \sum_{h=1}^H C_{i,t}^h + I_{i,t} + E_{i,t} + g_{i,t} \quad (9)$$

$$\bar{L}_t^h = \bar{L}_0^h e^{n^h, t} = L S_t^h + l_t^h \quad (10)$$

$$G_t = \sum_{i=1}^N g_{i,t} \quad (11)$$

Markets for goods clear but the economy may not always be in equilibrium. Imperfections either in goods or input markets are common giving rise to monopolistic or oligopolist situations. Such imperfections in the markets are often represented by appropriately designed mark-up schemes (Dixit and Stiglitz 1977). These mark ups may be sensitive to strategic interactions between consumers and producers, firms and government or between the national economy and the Rest of the World. With widening gap between number of vacancies and unemployed workers it is possible to incorporate the equilibrium unemployment features of Mortensen and Pissarides (1994) in the model.

2.6 Procedure for Calibration

Computation and calibration of dynamic models like this are discussed in greater details in the literature (Blanchard and Kahn 1980, Sims 1980, Rutherford 1995, Smet and Wouters 2003, den Haan and Marcet 1990, Sims 1980, Kehoe 1985, Taylor and Uhlig 1990, Harrison and Vinod 1992). This model is calibrated to

the reference path of the economy using the arbitrage condition in the capital market:

$$P_{i,t}^k = R_{i,t}^t - (1 - \delta_i) P_{i,t+1}^k \quad (12)$$

$$R_{i,t}^t = (r + \delta_i) P_{i,t} = (r + \delta_i) P_{i,t+1}^k \quad (13)$$

$$\frac{P_{i,t+1}^k}{P_{i,t}^k} = \frac{1}{1 + r_i} \approx (1 - \delta_i) \quad (14)$$

This helps to calibrate the capital stock and the level of investment in equilibrium path:

$$\bar{V}_{i,t} = (r + \delta_i) P_{i,t+1}^k K_{i,t}; \quad K_{i,t} = \frac{\bar{V}_{i,t}}{r_i + \delta_i}; \quad P_{i,t} = P_{i,t+1}^k \quad (15)$$

$$I_{i,t} = \frac{g_i + \delta_i}{r_i + \delta_i} \bar{V}_{i,t} \quad (16)$$

Even a small reform in the public policy of a sector can have a large impact on the welfare and growth over time if such policy has larger knock on effects in the wider economy and removes the root source of the distortions that can have a detrimental impact on output, employment and investment levels in the economy.

3 Data for the Benchmark Economy

In their seminal works Stone (1942-43; 1961) and Meade and Stone (1941) had developed methods to construct national account and input-output table of the UK economy. The latest versions these tables available from the Office of the National Statistics (<http://www.statistics.gov.uk/statbase/>) are used to construct the micro-consistent data for this model. Demand and supply sides for each production sector, income and expenditure for each category of household are balanced in it. The distribution of income and expenditure for different categories of households are taken from the Department of Work and Pension that is in process of unifying numerous benefits going to low income households (<http://www.dwp.gov.uk/research-and-statistics/>). Share parameters from these tables are used to decompose the labour and capital income as well as consumption across households. It assumes inter temporal balance of budget by the government during the model horizon allowing occasional deficits, like the current one, in the short run. It uses existing rates of direct and the indirect taxes that influence the stream of income and consumptions of households and input choices of firms. Detailed discussion of the microconsistent data set and algorithm and GAMS/MPSGE programmes are skipped here for space reasons.

Table 9: Central Values of Parameters of the Model

	values
Elasticity of substitution	1.15
Steady state growth rate	0.022
Benchmark interest rate	0.05
Intertemporal substitution	0.95
Rate of depreciation	0.02
VAT rate	0.20
Elasticity of transformation	2.00
Capital labour substitution	1.5
Armington substitution	1.2

Model uses literature based values of elasticities of substitution among inputs in production for each sector and the demand for consumption of various goods or between consumption goods and leisure for each household. Intertemporal elasticity of substitution provides trade-off between the current and future choices.

Thus the income redistribution effect in the model occurs not only through the differentiation in endowments but also by variations in tax rates on labour and capital income as well as full or reduced rate of VAT on consumption of goods and services and differentiated rates of subsidies and transfers according to criteria set for the households and firms in the economy. The optimal design of the tax system occurs by considering which one of these tax instruments is cost effective in raising a given amount of revenue and has the least distortions in choices of households and firms.

4 Results on Redistribution

Model solutions for the benchmark and counterfactual scenarios provide basis for the evaluation of the current tax and transfer system on both the functional and the size distribution of income for the next century which then could be compared to the historical accounts presented in section one. While the distribution of income between capital and labour are broadly determined by their marginal productivities as well as the amount of each factor used in production in line of standard neoclassical principles of firms and rates of taxes on the use of these inputs, the size distribution on the income of the households depend on socio-economic structure of the economy. It is the post tax income or the level of utility from composite of consumption and leisure that households care the most. In the model these are ultimately determined by inter and intra-temporal preferences of ten categories households and technological choices available to the producers in all eleven production sectors and the design of the tax-transfer system as proposed in Mirrlees (2011). These model solutions could fit to the available theories of distribution that emphasize on ability or stochastic factors

or individual choice or on human capital or on inheritance or educational inequality or life cycle or public choices for redistribution or justice as presented in Sahota (1978) or Aghion et al. (1999). The dynamic general equilibrium theory thus is the the most comprehensive theory of income distribution (Sen 1974, Auerbach, Kotlikoff and Skinner 1983, Huggett et al. 2011). Model solutions are used to compute the Gini coefficient to measure impacts of reform on distribution taking note of related literature such as Persson and Tabellini (1994), Mookherjee and Shorrocks (1982), Perotti (1993) and King (1983). We adopt Dorfman (1979) approach to compute the area under the Lorez curve for

$$L(u) \quad A = \int_0^1 L(u) du = \frac{1}{2\mu} \int_0^{y^*} (1 - F(y))^2 dy \quad \text{from the solution of the model}$$

for each year and apply Gini (Γ) coefficient as $\Gamma = \frac{A_e - A}{A_e}$ to measure the inequality of distribution (Figure). Since the level of utility is the most relevant indicator of the welfare of households we focus on growth and inequality in this variable that are caused by changes in the tax and transfer system. It is observed that more equality not necessarily brings the highest possible welfare to all households. While the welfare of every household can rise if the growth rate is higher but more equality with lower growth rate can reduce the level of the lifetime utility of households as is clear from the solution of the model (Fig. 12-14). This brings us to more difficult question of choosing an appropriate social welfare function based on comparison of all types of households in the model. Given utilities of individual households, $U(C_1), U(C_2) \dots U(C_{10})$ it is possible to compute the social welfare function $W = W\{U(C_1), U(C_2) \dots U(C_{10})\}$ which has desirable properties (Dasgupta et al. 1973). Philosophical controversy is in whether to use maxmin criterion of Rawls (1971) which requires finding of the welfare level of the lowest income household as the basis of the improvement in the social welfare or to adopt a weak equity axiom of Sen (1978) to justify Gini computed from the model solutions for ranking policies on the ground of distributional objective. In Atkinson's measure of inequality (I) with income density

$$\text{function } f(y_i) \text{ with mean income } \mu, I = 1 - \left[\sum_i \left(\frac{y_i}{\mu} \right)^{1-\epsilon} f(y_i) \right]^{\frac{1}{1-\epsilon}}, \text{ transfer}$$

to lower income is weightier in the social welfare function as the value of ϵ rise (Rawlsian case when $\epsilon \rightarrow \infty$) in the measure of inequality. By constraining revenue neutrality or social welfare neutrality of taxes and spending policies, the model presented here can generate optimal numerical values of tax rates that are consistent to the principles sets in Mirrlees (1971) or in Diamond-Mirrlees (1971). When tax rates are properly designed in this manner these can not only minimise the risks due to income uncertainty for low income households but also ensure that the economy moves along its long run steady state mitigating impacts of disturbances as seen in the current recession.

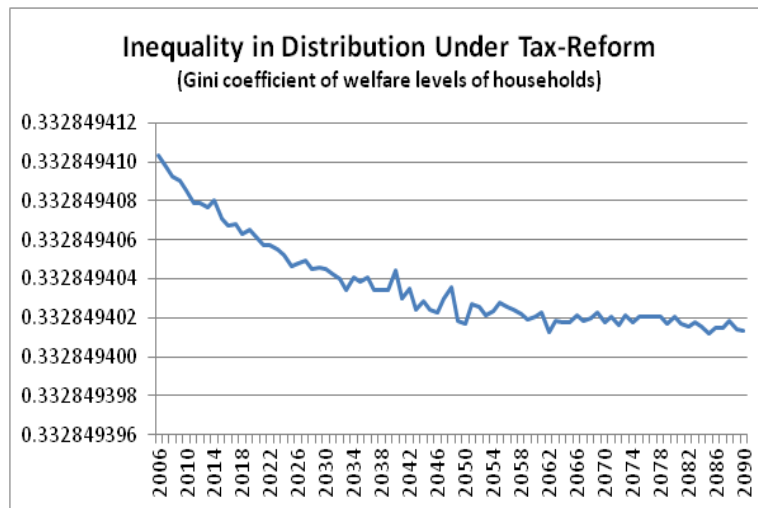


Fig. 11

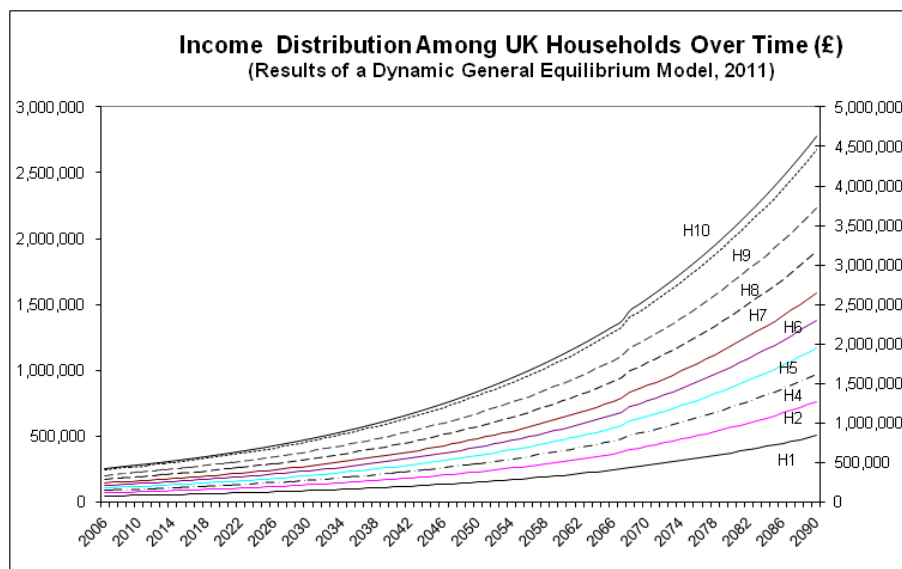


Fig. 12

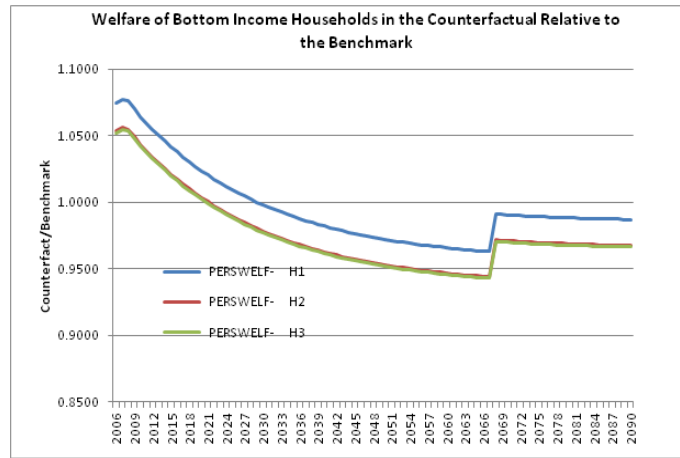


Fig. 13

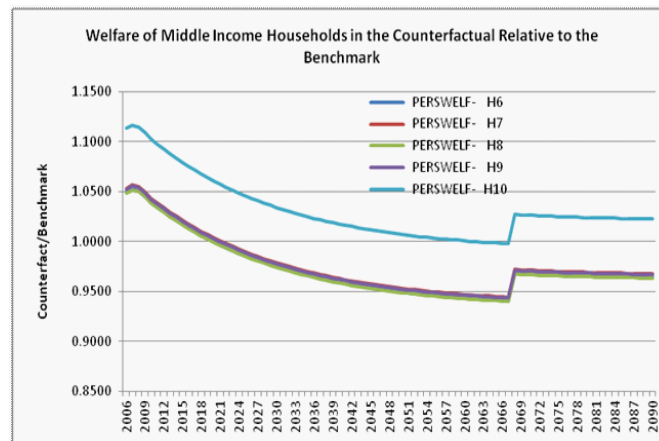


Fig. 14

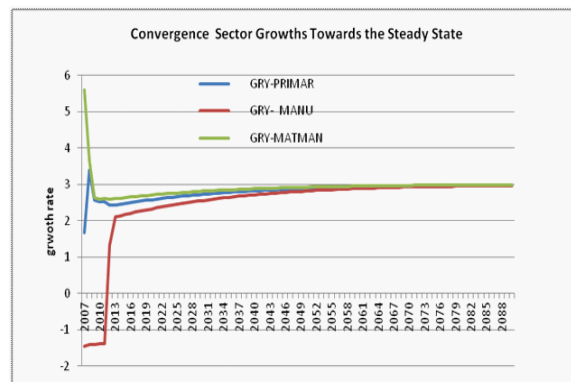


Fig. 15

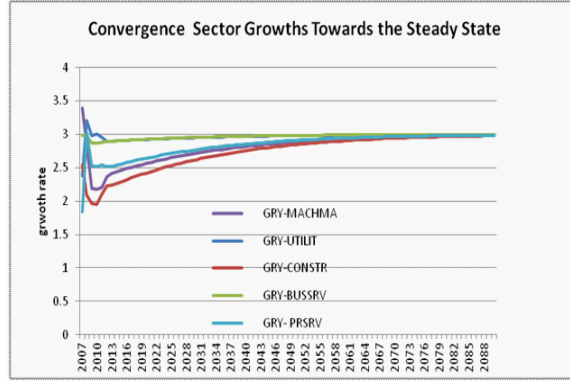


Fig. 16

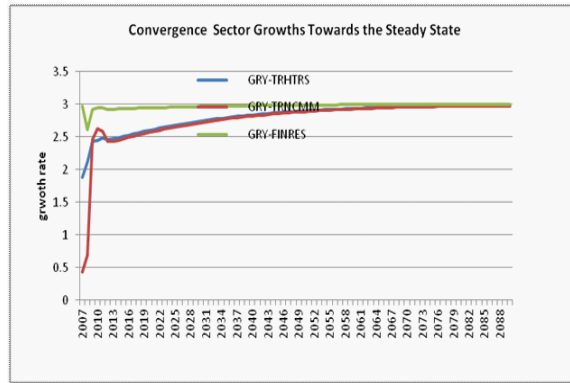


Fig. 17

Model results also help us to evaluate the impacts of current fiscal policies in the industrial composition over the long run (Fig. 15-17) though like any other models in economics it must be updated regularly according to the emerging features of the economy.

5 Conclusion

UK economy that grew annually at 2.05 percent in the last two centuries had experienced a rise in income inequality during the peak phase of the industrial revolution around 1850. Thus UK became the economic leader in the global economy in 19th century creating inequality in income distribution. Greater

concerns towards the plight of ordinary workers in the 19th century led to actions by trade unions, politicians and philanthropists that resulted in the promulgation of a series redistributive tax and transfers measures changing the focus of public finance from debt financing of wars to an egalitarian modern welfare state from the beginning of 20th century. Disappearance of the Kuznets curve phenomenon on inequality in both the original and the post tax income in the last five decades has caused quite a lot of discomfort and tension among people and policy makers particularly when the contribution of recent reforms to growth has become controversial. An attempt is made here to provide an evidence based on a dynamic multisectoral, multi-household general equilibrium model with tax and transfer calibrated to the input-output structure as well as preference and technological features of the UK economy. Model results are used to study the evolution of the whole economy in the 21st century. These show how the tax- transfer policies could be designed to prevent income inequality rising further and to ensure that growth rates of all sectors converge towards the steady state by the model horizon. Whether the growth enhancing and inequality reducing objectives could be achieved in the long run depend on degree of cooperative choices from low as well as high income households in response to the public policies aimed at realising the long run vision of the UK economy. Achieving greater equality by increasing the level of utility of all households would be a sensible policy and is possible from higher rate of economic growth. It is not easy to find such solutions if the compensation principles are not clear in setting up a social welfare function as the greater equality in income does not automatically guarantee greater welfare for everyone when the economy is not growing at a desirable space.

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