# Dynamic Multi-household General Equilibrium Models for Policy Simulations of Germany, France, Spain and UK

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# Abstract

The results of dynamic models presented here show evolution of four European economies for 84 years from 2006 to 2090, most parts of the 21st century. It shows how the rate of investment and accumulation of capital, level of production among all sectors, consumption and welfare of households, relative prices of goods and services, revenue and expenditure of the public sectors, exports, imports and net trade balance evolve over time. Inequality in the distribution of income among households will not decrease if the current policies continue, they will widen over time as shown in the solutions of dynamic general equilibrium models. Computations clearly show that the inequality will rise over coming decades not only in Germany but also in France, Spain and UK. In fact these economies tend to converge in the pattern of inequality. Skill-biased technical progress makes such gap inevitable in market economies. This is the reason for making education and skill formation at the central piece of the Lisbon Agenda.

***Key words:*** **growth, redistribution, EU, general equilibrium**

***JEL Classification:*** **C68, D63, O15**

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## I. Introduction

Macroeconomic stability, higher economic growth, greater efficiency in allocation of resources and more equal distributions for peace and prosperity are building blocks of the European economic policy. From the Treaty of Rome to the adoption of the Lisbon Agenda 2000 the European Union has made significant improvement in integration among its 27 member countries and European economy is becoming the most powerful, dynamic and vibrant economy in the global economy. This study aims to present a dynamic general equilibrium model of EU's four big economies, France, Germany, Spain and UK that represent about 250 million people, about 50 percent of EU's 500 million population. It builds on several studies relating to the single market project for European integration. For instance, Allen, Gasiorek, Smith, Flam, Sørensen (1998) had used inputs from an econometric model to a CGE model to assess the direct effect of reduction in trade barriers under the single market project . Their conclusion that the SMP had pro-competitive impacts and not only the nature but also the intensity of competition has increased on various industries in EU has sound theoretical basis. Baldwin, Francois, Portes, Rodrik, (1997) estimated costs and benefits of joining the EU and argued that risk premium of investment has reduced significantly after the implementation of the EU enlargement project. Their CGE model contained scale economies and Dixit-Stiglitz type monopolistic competition and model was calibrated to the GTAP database. Broer, Westerhout, Bovenberg (1994) using a small open economy model analysed how reducing the burden of income taxes and pay as you go (PAYG) contributions from labour income can improve labour supply, generate more efficiency, incentives and guarantee a Pareto improvement. Francois (1996) illustrated how higher rate of population growth in developing countries can erode real wages in developed

countries in factor based trade models and two way trade based on product differentiation. Haaland (1992) finds 1992 SMP project to have positive impact through enhancement of capital accumulation. Harrison, Rutherford and Tarr (1997) find the benefit of the Uruguay Round of trade negotiation between 96 to 171 billion in a GE model of 24 regions and 22 commodities. Haaland, Norman, Wergeland and Rutherford (1987) study comparative advantage under Ricardo-Hecksher-Ohlin-Jones framework in six region global economy model. Jensen and Rutherford (2002) explained how public debt reduction achieved through spending cuts hurts elderly poor though public goods and how transfers provided by surplus generated by debt reduction would benefit future poor. For them intergenerational equity is likely to pose a threat to the fiscal consolidation that is less likely to occur. Keuschnigg, Kohler, Casella and Sapir (1996) in overlapping generation model evaluate access into the EU which have impacts on expected capital accumulation, saving and investment activities, trade integration and effects of adoption of common agricultural policies, though the net gains are around 1.24 percent of GDP. The accession treaty favours old and future generations at the cost of current generation. Nordhaus and Yang (1996) presented a regional integration model of climate change and the economy and considered pure market solutions, efficient cooperative outcome and non-cooperation equilibrium. Emission is controlled more under the cooperation rather than in the non-cooperative solution though high income countries may be major losers from cooperation. Piazolo (2001) incorporates adjustment cost of investment in order to capture the non-steady state phenomenon in the benchmark in a standard CGE model. Saito (2004) illustrates how estimation of elasticities of substitution is different when estimated with bilateral rather than multilateral data. Wren-Lewis, Darby, Ireland and Ricchi (1996) compare econometric macroeconomic model to a simpler theoretical model and continue perturbations until properties match between econometric and theoretical models for analysis of fiscal policy under the COMPACT model.

Wright (1988) studies stochastic economy with labour contracts with overlapping generations and finite horizon employers to reconcile data with equilibrium theory. Krusell, Ohanian Ríos-Rull, and Violante (2000) show how skill biased technological changes is the main reason for the rising gap in wages of skilled and non-skilled workers. Despite[1] so much work on the European economies there are very few applied dynamic general equilibrium models available in the literature appropriate for analysing growth prospects in multi-household multisectoral set up. This part explains how to formulate a dynamic multi-household multisectoral dynamic general equilibrium model of those four countries in which households are differentiated by their labour and income categories and variation in consumption patterns. Producers supply goods and services for domestic markets and exports. Public sectors use tax and transfer policies and provide public services. First part introduces the model in general terms; second section provides a brief background in each of those four economies; third section presents macro series and the micro consistent benchmark data set used for calibration of the reference path for this dynamic economy. Forth section will include results of the model with many graphs used to show the dynamic path of the economy followed by conclusions, references and technical appendices on more precise description of model equations.

## II. Introduction to Dynamic General Equilibrium Models

Applied dynamic general equilibrium models of four EU economies presented here are based on intertemporal optimisation decisions of households and firms. In each period

[1] This is just an indication of related studies. Many other studies such as Abrego and Whalley(2000), Touhami, (1998) ,Armington (1969), Bhattarai (2007, 2001,1999) Bhattarai and Whalley (2006, 2003), Daniel and Blanchard (1988) ,Maureen and Oates (1992) ,Edwards and Whalley (2007). Haskel, and Slaughter (2001),Winchester, Greenaway and Reed (2006), Wright (1988), Robinson (2008) have modelled this issue from many different angles. Ecomod conference series have made good contributions.

demand for goods and services are derived from the preferences subject to life time budget constrains of households. Supply sides are derived from the profit maximisation decisions of firms. The interaction of these economies into the global economy is through exports and imports in which the balance of payment is maintained through adjustment in the exchange rates. The price system allocates resources efficiently in each period and over time. All economic agents do the best they can within their intertemporal budget constraints.

The computable general equilibrium modelling includes most of the theoretical developments in economics over last 200 years. It takes disaggregated micro-consistent data set for the economy and assesses equilibrium that emerge from various policy instruments available to the policy makers. It is fairly decentralised model aimed to replicate economic activities in an economy where the households are constrained by resources in deciding their optimal choices, firms are constrained by available technology in supplying commodities that are in demand in the markets, revenue and expenditure accounts of governments are balanced as are the exports and imports of the economy.

**Demand Side of the Economy**

Households differ in their preferences of goods and services and in their endowment of labour and capital. They pay taxes on labour and capital income and receive transfer payments from the government on mean tested basis. Demand functions are schedules what households would like to buy at given prices and are influenced by income and substitution effects of price changes over the model horizon. In the current context, they are myopic and base their decisions on life time income. They take prices of commodities as given and use the benchmark interest rate in order to discount their future earnings to get present value of life time income.

Utility in each period is a nested function. Consumption goods consist of CES aggregation of commodities. Household utility is derived from composite consumption good as well as leisure in each period. The marginal rate of substitution among commodities and between composite consumption good and leisure are influenced by the elasticity of substitution at the relevant nests of the utility function. Similarly the inter-temporal choices, consumption today versus consumption in the future and work or leisure today versus that of tomorrow are determined to a great extent by these elasticity parameters. Markets are more flexible when the values of these elasticities are higher than when they are lower. Impact of public tax and subsidy programmes in consumption and income inequalities depend to a large extent on these parameters.

In the current context model decomposes the household sector of these four economies by their income deciles. In this ranking H1 household is the poorest and H10 the richest in terms of income. All the remaining households are categorised in that order. Allocation between current and future consumption of these households is influenced by the elasticity of inter-temporal substitution between consumption and leisure. Economic theory cannot predict precisely how a household responds to an increase in the wage rate as the income and substitution effects move in opposite directions.

Demand for inputs, labour, capital and technology is derived from the demand for products. When demand for a product rises, it causes its prices to rise, this further raises demand for labour and capital in that sector.

**Supply side of the economy**

Firms behave competitively in this economy – they take prices of inputs and outputs as given and employ factors up to a point where the marginal productivity of that factor equals its remuneration. Production technology shows how inputs are transformed into

output. More efficient technology generates more output from given inputs. In general the level of technology is an outcome of the process of accumulation of human and physical capital. More education generates more skills and skilled workers are more productive than less skilled workers.

**Trade and Aggregate Supply**

A free trade allows economies to export goods in which it has more comparative advantage and import goods which are not in adequate supply in the home economy. The real exchange rates are determined by the ratios of average prices of tradable commodities at home and abroad. Households in the economy can raise their welfare by exporting goods which they can produce more efficiently and importing goods which they cannot produce efficiently.

Production and aggregate supply of the economy, similar to consumption is represented by a set of nested functions. Initially labour and capital inputs determine the value added for a given sector. Inter-industry linkages are given in the beginning by the coefficients of the input-output table. The gross output of any sector can be exported to foreign markets or supplied to domestic markets. Following standard Armington product differentiation, imported goods compete with the domestic products in supply in forming the aggregate supply of the economy. Volumes of exports and imports balance for each period in some scenarios and intertemporally in others.

**Public sector**

Governments provide public goods and transfer income to household collecting from direct and indirect taxes. In European countries modelled here direct income taxes are more important than indirect one such as value added tax. Government provides social insurance to low income households who are vulnerable to market conditions. The impacts of public

programmes in welfare of households are measured in terms of money metric utility functions. The income gap between the rich and poor may be higher without transfer programmes or without good provision of public services such as education and health.

**Markets and the relative prices**

Markets determine prices by reconciling demand for products by households and demand for inputs by firms to supply of commodities by firms and supply of factors by the owners of factor services. Prices adjust until the demands equal supplies. Market clears dynamically in the sense that the demand for products by households equals supply of products by firms and saving by households equals investment by firms. The Pareto optimality is achieved in each period – there is no alternative allocation which can make an economic agent better off without making another worse off. Public sector tax and transfer policies impact households through their impacts on these relative prices.

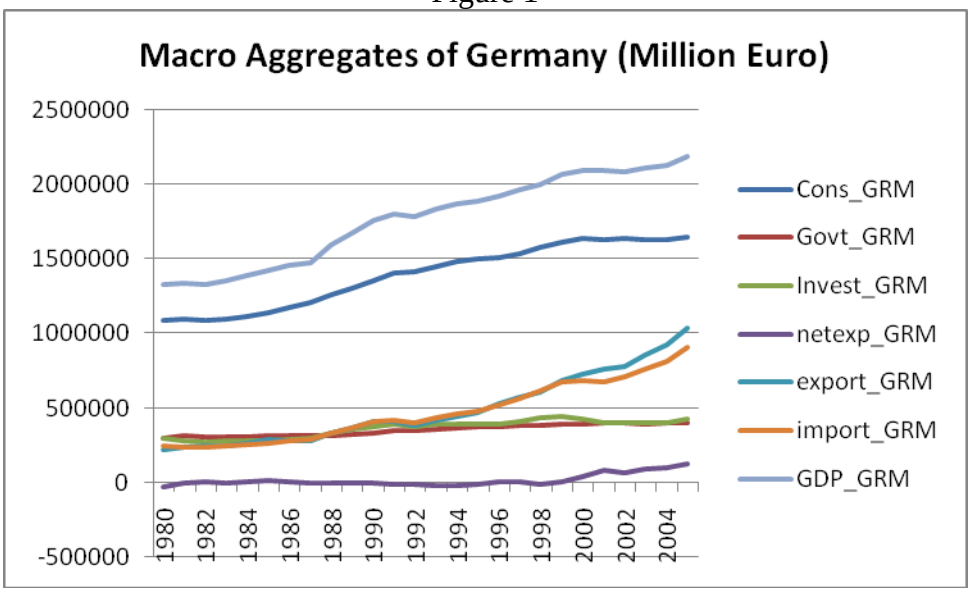
## III. Macro Trends and Microconsistent Benchmark Data Set

This section briefly presents major challenges and constraints faced by each of the four major economies contained in this study with macro trends and micro consistent data required to benchmark the economy.

**Germany**

After successful decades of speedier economic growth the German economy slowed down in mid 1990s. Unemployment rate is still around 7 percent of the workforce, financial troubles have affected the flow of credits recently and the unit labour costs are rising, fluctuations in construction activities and housing markets and slow down of exports because of reduction in competitiveness due to appreciation of Euro relative to other major currencies and reduction in global demand are posing threats on economic growth. Rising food and energy prices are likely to keep upward pressure in inflation. There are concerns on rising wage inequality.

Figure 1




The dynamic general equilibrium model of Germany takes above realities under consideration and builds on the micro-consistent data set from the Input-Output table of Germany as given in Table 1. Service sectors comprise around 60 percent and the manufacturing around 20 percent of the economy: private services (16%), tourism-hotel and restaurants (13%), finance and real estate (10%), business services (11%) and transport and communication (6%)

Table 1 (a)
Input-Output Transaction Table for Germany

| | Primary | Manu | MatManu | Machman | Utility | Constru | TRHTRST | TRNCMM | FINREST | BUSSRV | PRSRV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Primary | 2718 | 35960 | 31325 | 799 | 4974 | 2283 | 1717 | 379 | 891 | 394 | 2289 |
| Manu | 4375 | 43348 | 7290 | 6716 | 108 | 8584 | 14610 | 528 | 635 | 610 | 8478 |
| MatManu | 6261 | 20204 | 155823 | 91274 | 3238 | 46371 | 18009 | 9428 | 3133 | 7827 | 16544 |
| Machman | 2271 | 3545 | 13458 | 176105 | 4018 | 13668 | 9071 | 7065 | 1449 | 3512 | 12942 |
| Utility | 1641 | 3455 | 11378 | 4565 | 3089 | 509 | 5025 | 2327 | 1816 | 1488 | 5449 |
| Constru | 1073 | 1140 | 3631 | 3080 | 1845 | 5560 | 3073 | 2333 | 18184 | 2259 | 7887 |
| TRHTRST | 3111 | 12414 | 16180 | 21302 | 1431 | 9776 | 23608 | 7294 | 1336 | 4077 | 11411 |
| TRNCMM | 1331 | 7203 | 15180 | 16333 | 1413 | 3693 | 12045 | 64052 | 4672 | 4622 | 12161 |
| FINREST | 1906 | 6505 | 14552 | 14897 | 3049 | 22752 | 40787 | 9386 | 79174 | 21705 | 22605 |
| BUSSRV | 5722 | 18510 | 41951 | 44076 | 6834 | 12964 | 29434 | 13544 | 50591 | 53838 | 29702 |
| PRSRV | 2164 | 2402 | 8577 | 2544 | 4635 | 1500 | 9268 | 2316 | 4842 | 14094 | 34441 |

Data Source: OECD, DSTO/DOC(2006)8

Table 1 (b)
Value added, Final Demand and production Taxes for Germany

| | Primary | Manu | MatManu | Machman | Utility | Constru | TRHTRST | TRNCMM | FINREST | BUSSRV | PRSRV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Capital | 17209 | 20979 | 47323 | 23148 | 16614 | 27837 | 51196 | 46146 | 227050 | 139478 | 96230 |
| Wages | 15870 | 43810 | 114080 | 152750 | 15780 | 65210 | 158090 | 61370 | 64650 | 101660 | 306690 |
| Prodtax | -4983 | 2026 | 6043 | 4229 | 2513 | 2452 | 11879 | 4872 | 16750 | 2356 | 8212 |
| Conshh | 20715 | 145901 | 69456 | 75220 | 24741 | 4607 | 225554 | 69690 | 241371 | 14698 | 147103 |
| Cons_gov | 128 | 1269 | 8463 | 4033 | 334 | 816 | 11370 | 2966 | 3592 | 5697 | 342683 |
| GFCFR | 3318 | 9387 | 16058 | 151324 | 2917 | 169171 | 14325 | 5899 | 3830 | 30274 | 5478 |
| Export | 5703 | 43103 | 164654 | 260311 | 1476 | 2082 | 34403 | 33646 | 2973 | 19255 | 2826 |
| Imports | 52917 | 73441 | 149952 | 176171 | 670 | 3578 | 9782 | 23867 | 13912 | 19169 | 9834 |

Data Source: OECD, DSTO/DOC(2006)8

Table 1 (c)
Share of income, consumption, labour and capital income in Germany

| | h1 | h2 | h3 | h4 | h5 | h6 | h7 | h8 | h9 | h10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incshare | 0.0322 | 0.0530 | 0.0686 | 0.0686 | 0.0890 | 0.0890 | 0.1155 | 0.1155 | 0.1481 | 0.2207 |
| Consshare | 0.0320 | 0.0530 | 0.0685 | 0.0685 | 0.0890 | 0.0890 | 0.1155 | 0.1155 | 0.1480 | 0.2210 |
| Capital | 22965.36 | 37800.12 | 48926.20 | 48926.20 | 63440.02 | 63440.02 | 82340.08 | 82340.08 | 105626.39 | 157405.42 |
| Wages | 35418.71 | 58297.88 | 75457.26 | 75457.26 | 97841.44 | 97841.44 | 126990.38 | 126990.38 | 162904.08 | 242761.17 |
| Conshh | 33249.76 | 55069.92 | 71175.27 | 71175.27 | 92475.90 | 92475.90 | 120010.85 | 120010.85 | 153780.14 | 229631.16 |

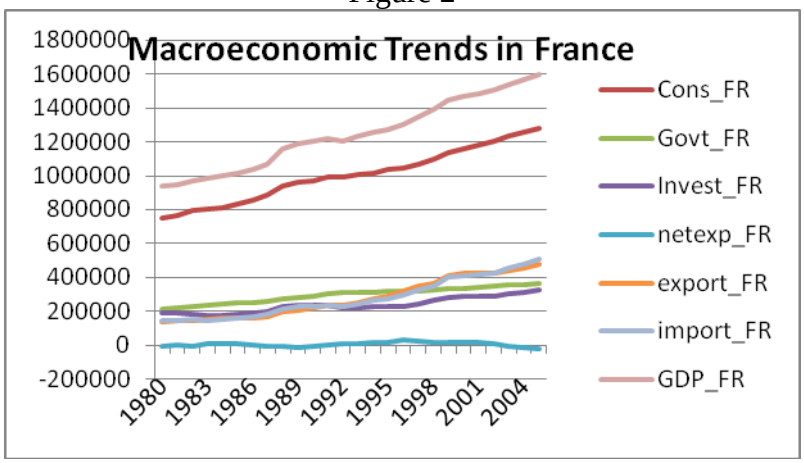
Data Source: OECD, DSTO/DOC(2006)8 World Bank data at www.mimas.ac.uk for income and Table 2.7 of WDI for consumption Share.

Above tables show how various sectors of the German economies are related to each other. Technology transaction matrix in Table 1(1) shows Input-Output inter-sectoral linkages, and the sector-wise links on value added and the final demand is presented in Table 1(b) and distribution of income and consumption patterns across households is presented in Table 1(c).

**France**

Uncertainty in housing and financial markets is likely to slow down growth rates of output and rate of job creation in France. Upward pressures in wage rates have raised the unit labour cost and reduced the rate of employment creation. Further net exports are falling because of the slowdown in global demand and erosion of competitiveness due to appreciation of Euro. Raising the rate of productivity growth and enhancing the skill of the work force are in major agenda for labour market reforms.

Figure 2




Service sector constitutes about 58 percent and the manufacturing about 30 percent of the French GDP. Proportionately to the size of GDP the wage income in the private and business services are much higher than other sectors. More than 50 percent of national income goes to households in top three deciles.

Table 2 (a)
Input Output Table of France

| | Primary | Manu | MatManu | Machman | Utility | Constru | TRHTRST | TRNCMM | FINREST | BUSSRV | PRSRV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Primary | 11739 | 31811 | 23653 | 35 | 5466 | 2577 | 1747 | 15 | 16 | 95 | 2067 |
| Manu | 6417 | 36129 | 5087 | 3704 | 26 | 4304 | 10810 | 737 | 1453 | 1028 | 9501 |
| MatManu | 8550 | 17561 | 109128 | 45261 | 3933 | 21534 | 10377 | 7539 | 3593 | 12225 | 17932 |
| Machman | 2628 | 1935 | 6781 | 99367 | 853 | 9201 | 3344 | 7564 | 994 | 8146 | 10964 |
| Utility | 959 | 2443 | 5902 | 1727 | 5984 | 395 | 2710 | 907 | 711 | 946 | 5175 |
| Constru | 523 | 253 | 1682 | 570 | 2459 | 18955 | 985 | 390 | 2416 | 1074 | 5732 |
| TRHTRST | 3093 | 6836 | 11115 | 10439 | 232 | 4529 | 14725 | 2042 | 981 | 5066 | 8413 |
| TRNCMM | 1222 | 4405 | 10590 | 4245 | 504 | 2791 | 12233 | 42415 | 5257 | 11679 | 10230 |
| FINREST | 2041 | 6136 | 7885 | 6333 | 1471 | 10360 | 18571 | 6636 | 42577 | 14996 | 18179 |
| BUSSRV | 1950 | 17724 | 28227 | 33167 | 4614 | 17657 | 14928 | 8701 | 26126 | 57193 | 23378 |
| PRSRV | 607 | 1606 | 3869 | 3336 | 1107 | 1483 | 2420 | 1624 | 3718 | 6572 | 13475 |

Data Source: OECD, DSTO/DOC(2006)8

Table 2 (b)
Value added, Final Demand and production Taxes for France

| | Primary | Manu | MatManu | Machman | Utility | Constru | TRHTRST | TRNCMM | FINREST | BUSSRV | PRSRV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Capital | 27835 | 20683 | 37599 | 18944 | 12421 | 19514 | 48867 | 27192 | 152201 | 56339 | 59525 |
| Wages | 9079 | 31161 | 59709 | 48630 | 10569 | 37910 | 106261 | 49965 | 47681 | 103165 | 233997 |
| Prodtax | 1607 | 4654 | 15216 | 11684 | 3391 | 6837 | 14024 | 8931 | 19052 | 11160 | 16163 |
| Conshh | 21454 | 109208 | 47331 | 47392 | 21746 | 7502 | 165238 | 41960 | 150087 | 12207 | 95474 |
| Consgov | 3 | 32 | 10244 | 856 | 11 | 43 | 6619 | 370 | 10509 | 7207 | 293960 |
| GFFCFR | 2138 | 4395 | 15746 | 81476 | 633 | 115462 | 9541 | 1834 | 10102 | 34869 | 4117 |
| Export | 10068 | 47065 | 98407 | 149023 | 3048 | 0 | 16197 | 22272 | 3024 | 19227 | 3742 |
| Imports | 34633 | 56559 | 102918 | 143080 | 268 | 0 | 3061 | 7347 | 2131 | 17493 | 2379 |

Data Source: OECD, DSTO/DOC(2006)8

Table 2 (c)
Share of income, consumption, labour and capital income in France

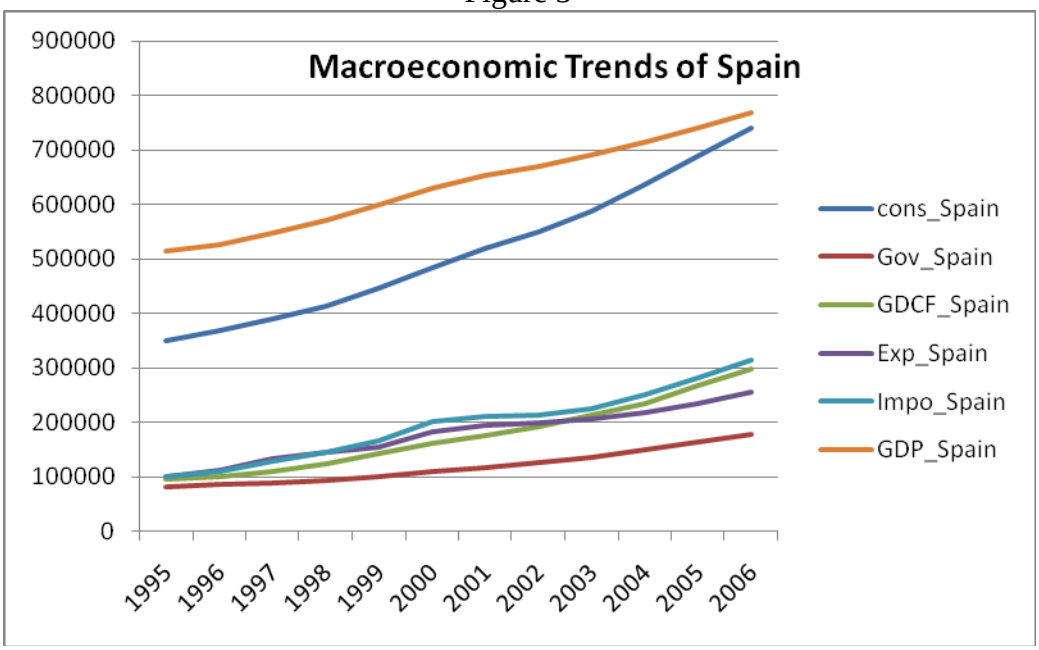
| | h1 | h2 | h3 | h4 | h5 | h6 | h7 | h8 | h9 | h10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incshare | 0.0275 | 0.0443 | 0.0631 | 0.0631 | 0.0860 | 0.0860 | 0.1140 | 0.1140 | 0.1512 | 0.2509 |
| Consshare | 0.0280 | 0.0440 | 0.0630 | 0.0630 | 0.0860 | 0.0860 | 0.1140 | 0.1140 | 0.1510 | 0.2510 |
| Capital | 13230.77 | 21313.57 | 30358.61 | 30358.61 | 41352.18 | 41352.18 | 54847.57 | 54847.57 | 72745.19 | 120712.76 |
| Wages | 20298.49 | 32699.03 | 46575.81 | 46575.81 | 63442.02 | 63442.02 | 84146.48 | 84146.48 | 111604.80 | 185196.06 |
| Conshh | 20148.74 | 31662.30 | 45334.66 | 45334.66 | 61885.41 | 61885.41 | 82034.15 | 82034.15 | 108659.27 | 180619.05 |

Data Source: OECD, DSTO/DOC(2006)8

**Spain**

Spain had enjoyed relatively stable growth in output in the last decade despite a higher rate of unemployment. However recent tormoil in financial and housing markets is leading it towards diminished expectations not only arising from a global recession but also due to lower rates of job creation, higher ratio of trade deficit, higher rates of expected inflation and a pressure in public budget .

Figure 3




Spanish economy has relatively larger manufacturing sector (46%) and smaller services sector (35%) than of other three economies. Income and wage distributions are more unequal.

Table 3 (a)
Input Output Table of Spain

| | Primary | Manu | MatManu | Machman | Utility | Constru | TRHTRST | TRNCMM | FINREST | BUSSRV | PRSRV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Primary | 3368 | 22010 | 16903 | 25 | 4684 | 1134 | 2151 | 16 | 30 | 18 | 437 |
| Manu | 5564 | 29048 | 2383 | 1227 | 35 | 2639 | 16069 | 510 | 83 | 1003 | 2042 |
| MatManu | 4439 | 11549 | 50776 | 23065 | 2520 | 23923 | 4248 | 5055 | 1016 | 4131 | 6813 |
| Machman | 784 | 1276 | 6278 | 34162 | 499 | 4699 | 4681 | 2803 | 128 | 1171 | 3756 |
| Utility | 861 | 1397 | 4770 | 855 | 2325 | 393 | 2821 | 585 | 344 | 724 | 2167 |
| Constru | 274 | 269 | 747 | 243 | 269 | 16079 | 1832 | 584 | 9413 | 588 | 2084 |
| TRHTRST | 1626 | 4775 | 6037 | 2146 | 192 | 5667 | 6770 | 5153 | 517 | 1514 | 2609 |
| TRNCMM | 1846 | 6612 | 10310 | 3033 | 349 | 2978 | 6427 | 13620 | 1860 | 2722 | 3875 |
| FINREST | 1126 | 2178 | 3154 | 1571 | 792 | 2842 | 11556 | 2766 | 10262 | 4234 | 5781 |
| BUSSRV | 404 | 4487 | 7330 | 3936 | 777 | 5223 | 5884 | 3752 | 2684 | 7925 | 6356 |
| PRSRV | 446 | 1071 | 1662 | 526 | 164 | 581 | 1754 | 763 | 504 | 1715 | 6129 |

Data Source: OECD, DSTO/DOC(2006)8

Table 3 (b)
Value added, Final Demand and production Taxes for Spain

| | Primary | Manu | MatManu | Machman | Utility | Constru | TRHTRST | TRNCMM | FINREST | BUSSRV | PRSRV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Capital | 17626 | 9132 | 16915 | 6365 | 8814 | 14598 | 63417 | 23003 | 51897 | 12055 | 18119 |
| Wages | 5190 | 19533 | 29216 | 18782 | 2978 | 30908 | 42831 | 21519 | 17757 | 24634 | 86529 |
| Prdntax | -1270 | -2699 | 904 | 138 | -56 | 1261 | 2481 | 2133 | 5115 | 519 | 4319 |
| Conshh | 6642 | 51587 | 18682 | 20947 | 6603 | 3272 | 124237 | 20328 | 46279 | 8274 | 35697 |
| Consgov | 8 | 43 | 4291 | 150 | 6 | 7 | 2397 | 710 | 1 | 83 | 99780 |
| GFFCFR | 760 | 3474 | 5163 | 35543 | 401 | 76977 | 2541 | 1468 | 8163 | 10317 | 880 |
| Export | 8307 | 20049 | 39515 | 52322 | 208 | 294 | 7828 | 11139 | 1973 | 8631 | 1394 |
| Imports | 24209 | 25116 | 47801 | 73124 | 118 | 9 | 1087 | 5013 | 1305 | 13112 | 2050 |

Data Source: OECD, DSTO/DOC(2006)8

Table 3 (c)
Share of income, consumption, labour and capital income in Spain

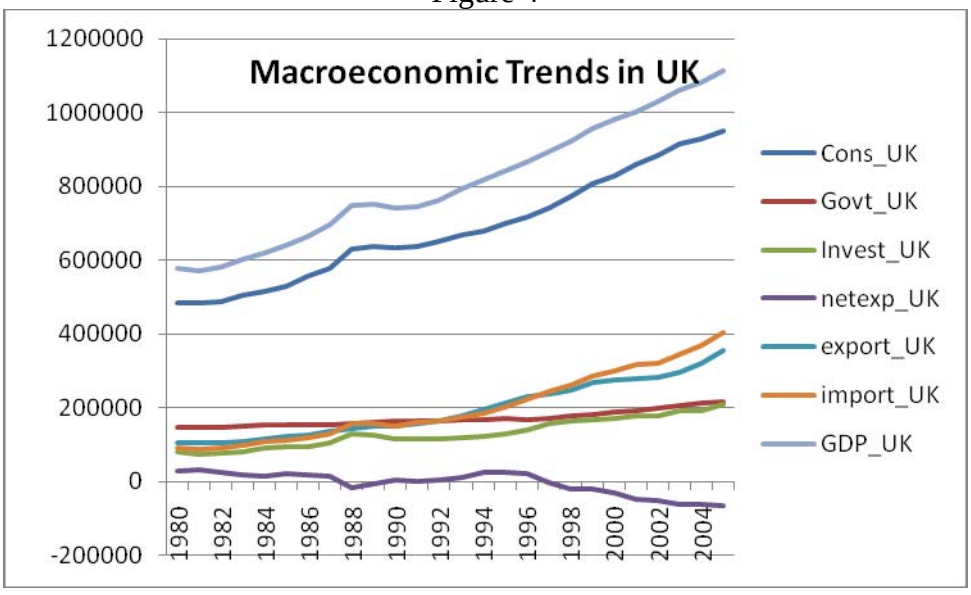
| | h1 | h2 | h3 | h4 | h5 | h6 | h7 | h8 | h9 | h10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incshare | 0.0257 | 0.0440 | 0.0605 | 0.0605 | 0.0822 | 0.0822 | 0.1126 | 0.1126 | 0.1539 | 0.2661 |
| Consshare | 0.0260 | 0.0440 | 0.0605 | 0.0605 | 0.0820 | 0.0820 | 0.1125 | 0.1125 | 0.1540 | 0.2660 |
| intr | 6217.9 | 10645.4 | 14625.3 | 14625.3 | 19875.4 | 19875.4 | 27230.4 | 27230.4 | 37234.7 | 64380.4 |
| wage | 7706.8 | 13194.6 | 18127.6 | 18127.6 | 24634.9 | 24634.9 | 33751.2 | 33751.2 | 46151.1 | 79797.3 |
| Conshh | 8906.3 | 15072.2 | 20724.2 | 20724.2 | 28089.0 | 28089.0 | 38536.8 | 38536.8 | 52752.6 | 91118.1 |
| Leisure | 5780.1 | 9895.9 | 13595.7 | 13595.7 | 18476.2 | 18476.2 | 25313.4 | 25313.4 | 34613.3 | 59848.0 |

Data Source: OECD, DSTO/DOC(2006)8

**U K**

Growth rate of output and creation of employment had been smooth and uninterrupted in UK in last 15 years particularly after the operational independence of the Bank of England on monetary policy with a clear mandate of stabilising the price level in 1997. New deal programs and education and employment policies had been successful in creating jobs though there are some concerns regarding the rising gap between wages of skilled and unskilled workers in recent years.

Figure 4



UK economy is dominated by service sectors which accounts around 65 percent of total economic activities; private services (18%), tourism-hotel and restaurants (15%), finance and real estate (12%), business services (11%) and transport and communication (8%). Distributions of wages are more unequal across sectors and across households when compared to Germany, France and Spain.

Table 4 (a)
Input Output Table of UK

| | Primary | Manu | MatManu | Machman | Utility | Constru | TRHTRST | TRNCMM | FINREST | BUSSRV | PRSRV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Primary | 4894 | 8984 | 13549 | 51 | 8679 | 2319 | 1826 | 243 | 152 | 240 | 601 |
| Manu | 1509 | 14435 | 3260 | 1479 | 80 | 2550 | 14753 | 886 | 707 | 1133 | 4388 |
| MatManu | 2966 | 10251 | 42359 | 22719 | 1210 | 12526 | 9282 | 6568 | 5537 | 5387 | 14439 |
| Machman | 1015 | 2178 | 4502 | 38747 | 985 | 3303 | 6360 | 8106 | 1463 | 2863 | 15696 |
| Utility | 704 | 1485 | 3938 | 1641 | 16801 | 393 | 2027 | 941 | 904 | 1206 | 2739 |
| Constru | 825 | 280 | 622 | 412 | 569 | 27619 | 1640 | 1564 | 9889 | 841 | 4585 |
| TRHTRST | 2659 | 9933 | 13218 | 13115 | 703 | 4892 | 14015 | 5126 | 3613 | 4120 | 10920 |
| TRNCMM | 1362 | 3545 | 6805 | 3192 | 365 | 1727 | 29331 | 30061 | 18767 | 8462 | 9603 |
| FINREST | 2779 | 3760 | 7285 | 5699 | 1380 | 5869 | 21927 | 6678 | 20526 | 8164 | 11586 |
| BUSSRV | 2028 | 4858 | 7318 | 6501 | 1374 | 7813 | 22711 | 14639 | 28627 | 48562 | 24121 |
| PRSRV | 614 | 952 | 2861 | 1357 | 314 | 667 | 2987 | 3040 | 4988 | 7112 | 0 |

Data Source: OECD, DSTO/DOC(2006)8

Table 4 (b)
Value added, Final Demand and production Taxes for UK

| | Primary | Manu | MatManu | Machman | Utility | Constru | TRHTRST | TRNCMM | FINREST | BUSSRV | PRSRV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Capital | 26537 | 9910 | 13109 | 9826 | 9345 | 19347 | 37196 | 20480 | 79837 | 34277 | 30218 |
| Wages | 6207 | 23942 | 50056 | 36519 | 4850 | 23637 | 82230 | 45321 | 37008 | 70597 | 151951 |
| Prdtax | 1090 | 2485 | 4619 | 3345 | 2555 | 4204 | 13705 | 7442 | 6267 | 5416 | 7826 |
| Conshh | 11347 | 77290 | 43828 | 47161 | 16043 | 4092 | 135849 | 36316 | 108326 | 11082 | 81348 |
| Consgov | 24 | 0 | 0 | 0 | 0 | 0 | 18 | 2 | 0 | 145 | 176902 |
| GFCFR | 1887 | 4068 | 8368 | 47980 | 577 | 63768 | 12516 | 1764 | 2903 | 11027 | 3243 |
| Export | 16694 | 11335 | 41235 | 77902 | 210 | 224 | 32351 | 12647 | 14541 | 24662 | 6608 |
| Imports | 16280 | 40870 | 53157 | 113677 | 397 | 63 | 3059 | 12855 | 3138 | 17087 | 4321 |

Data Source: OECD, DSTO/DOC(2006)8

Table 4 (c)
Share of income, consumption, labour and capital income in UK

| | h1 | h2 | h3 | h4 | h5 | h6 | h7 | h8 | h9 | h10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Incshare | 0.0206 | 0.0408 | 0.0571 | 0.0571 | 0.0798 | 0.0798 | 0.1125 | 0.1125 | 0.1553 | 0.2849 |
| Consshare | 0.0210 | 0.0400 | 0.0570 | 0.0570 | 0.0800 | 0.0800 | 0.1125 | 0.1125 | 0.1550 | 0.2850 |
| Capital | 5975.69 | 11835.35 | 16549.18 | 16549.18 | 23148.54 | 23148.54 | 32619.72 | 32619.72 | 45049.73 | 82644.36 |
| Wages | 10965.75 | 21718.57 | 30368.74 | 30368.74 | 42478.98 | 42478.98 | 59859.16 | 59859.16 | 82668.99 | 151657.40 |
| Conshh | 12026.31 | 22907.26 | 32642.85 | 32642.85 | 45814.52 | 45814.52 | 64426.67 | 64426.67 | 88765.63 | 163214.23 |

Data Source: OECD, DSTO/DOC(2006)8

As illustrated above the micro-consistent data for the dynamic general equilibrium model is constructed from the Input-output table for year 2006 obtained from the OECD. The distribution of income across households and their consumption patterns also take account of the data from the World Bank. Central values of elasticity parameters are determined on the basis of literature as presented below.

Table 5

**Elasticities and Growth and Interest Rates in the Benchmark**

| | |
|---|---|
| Elasticity of substitution | 1.5 |
| Steady State growth rate of output | 0.03 |
| Benchmark interest rate | 0.05 |
| Rate of depreciation | 0.02 |
| Intertemporal substitution elasticity | 0.95 |
| Elasticity of substitution on capital and labour | 1.5 |
| Armington elasticities | 1.2 |
| Household income tax rates (vary by household) | |
| Ealsticity of substitution in public consumption | 1.5 |

Table 6

Structure of Taxes on Inputs

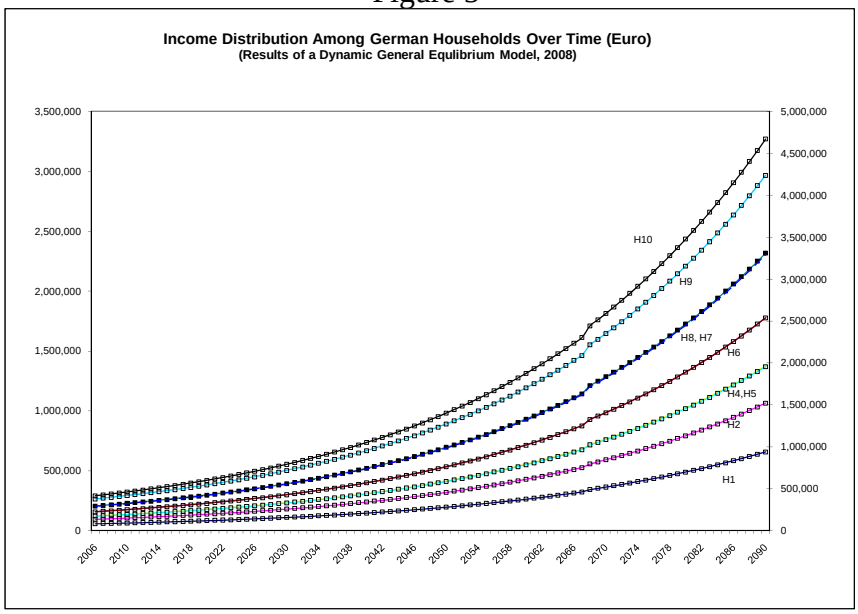
| | UK | | Germany | | France | | Spain | |
|---|---|---|---|---|---|---|---|---|
| | captax | labtax | captax | labtax | captax | labtax | captax | labtax |
| Primary | 0.01 | 0.13 | 0.01 | 0.13 | 0.01 | 0.13 | -0.02 | -0.18 |
| Manu | 0.06 | 0.08 | 0.06 | 0.11 | 0.06 | 0.11 | -0.07 | -0.10 |
| MatManu | 0.09 | 0.07 | 0.10 | 0.19 | 0.10 | 0.19 | 0.01 | 0.02 |
| Machman | 0.09 | 0.07 | 0.15 | 0.18 | 0.15 | 0.18 | 0.01 | 0.01 |
| Utility | 0.07 | 0.40 | 0.07 | 0.24 | 0.07 | 0.24 | 0.00 | -0.01 |
| Constru | 0.05 | 0.13 | 0.09 | 0.14 | 0.09 | 0.14 | 0.02 | 0.03 |
| TRHTRST | 0.09 | 0.13 | 0.07 | 0.10 | 0.07 | 0.10 | 0.01 | 0.04 |
| TRNCMM | 0.09 | 0.12 | 0.08 | 0.13 | 0.08 | 0.13 | 0.02 | 0.07 |
| **FINREST** | **0.02** | **0.13** | **0.03** | **0.30** | **0.03** | **0.30** | **0.02** | **0.22** |
| BUSSRV | 0.04 | 0.06 | 0.05 | 0.08 | 0.05 | 0.08 | 0.01 | 0.02 |
| PRSRV | 0.06 | 0.04 | 0.07 | 0.05 | 0.07 | 0.05 | 0.06 | 0.04 |

This model contains much more on data series and input-output tables. It is not presented here for space reasons. Counterfactual scenarios here eliminate taxes on real estate sector.

# IV. Analysis of Results

The dynamic model presented here shows evolution of the economy for 84 years from 2006 to 2090, most parts of the 21st century. It shows how the rate of investment and accumulation of capital, level of production among all sectors, consumption and welfare of households, relative prices of goods and services, revenue and expenditure of the public sectors, exports, imports and net trade balance evolve over time. Inequality in the distribution of income among households will not decrease if the current policies continue, they will widen over time as shown in from the solutions of dynamic general equilibrium model as presented in Figures.

Figure 5




Model computations clearly show the inequality will rise over the decades to come not only in Germany but also in France, Spain and UK. In fact these economies tend to converge in the pattern of inequality.

Figure 6

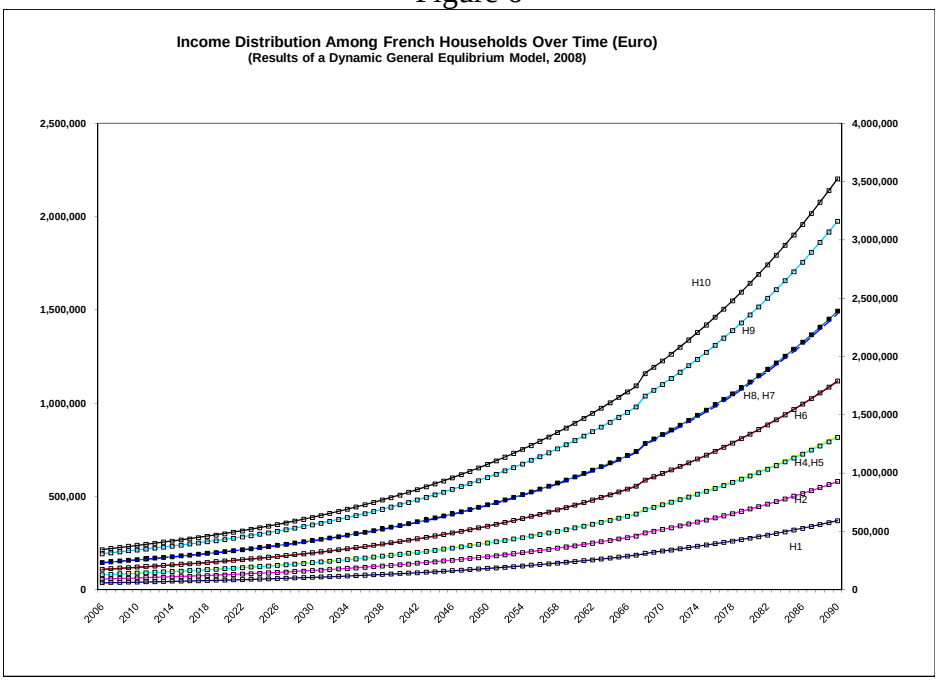


Figure 7

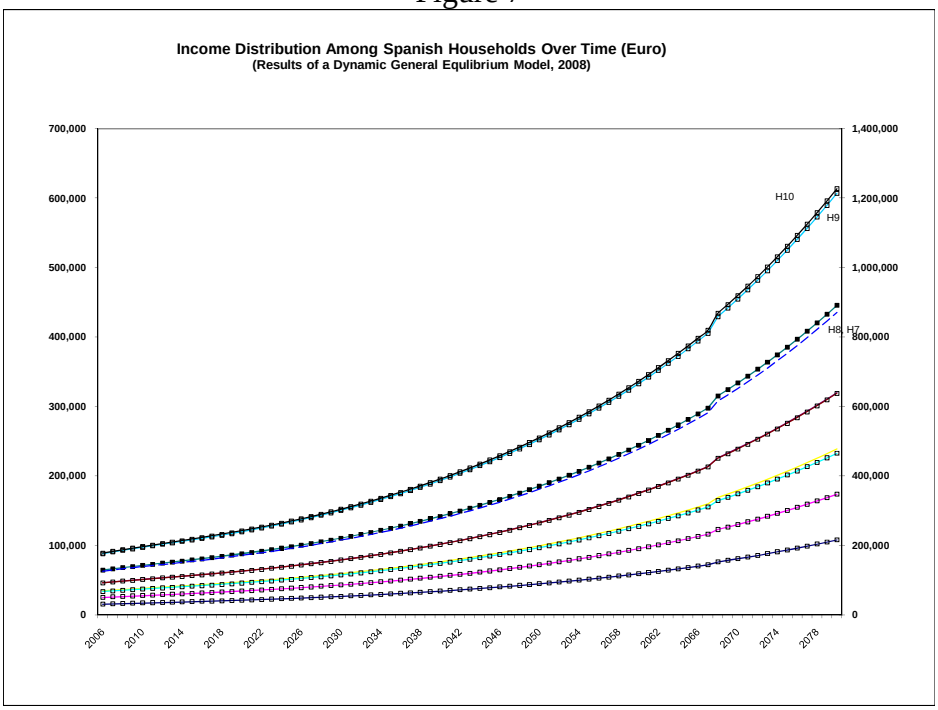
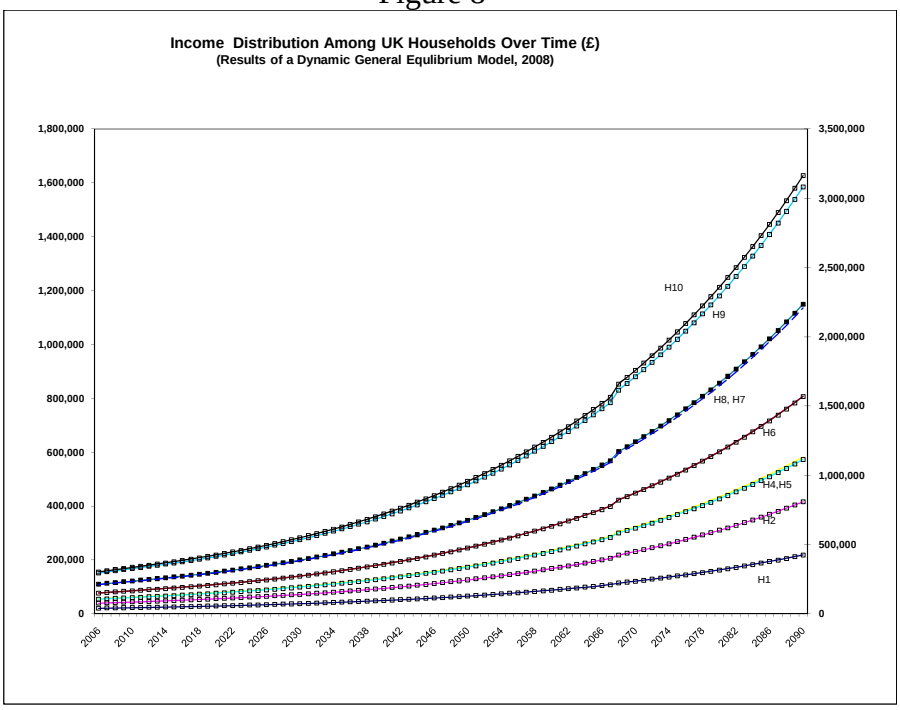



Figure 8



Computation of the dynamic general equilibrium model supports the basic results discussed in Krusell, Ríos-Rull, and Violante (2000). Skill-biased technical progress makes such gap inevitable in market economies. This is the reason for making education and skill formation at the central piece of Lisbon Agenda.

## Technical Appendix 1
## Dynamic General Equilibrium Model of Germany, France, Spain and UK: Model Equations

Model contains $i = 1...4$ countries and $h = 1....10$ households. Each household in each country receives utility from consumption of goods and leisure. Its objective is to maximise lifetime utility against their life time budget constraints. They receive income supplying labour and capital services to firms which pay them according to the marginal productivity. Lower income households receive transfers from the government which collects revenue by taxing high income households.

$$\text{Max } U_0^{i,h} = \sum_{t=0}^{\infty} \beta^{i,t} U_t^{i,h}\left(C_t^{i,h}, l_t^{i,h}\right) \quad (1)$$

Subject to

$$\sum_{t=0}^{\infty} R_{i,t}^{-1}\left[P_{i,t}(1+t^{i,vc})C_t^{i,h} + w_{i,t}(1-t_{i,l})l_t^h\right] = \sum_{t=0}^{\infty}\left[(1-t_l)w_{i,t}L_t^{i,h} + (1-t_{i,k})r_{i,t}K_t^{i,h} + TR_t^{i,h}\right] \quad (2)$$

where $C_t^{i,h}$, $l_t^{i,h}$ and $L_t^{i,h}$ are respectively composite consumption, leisure and labour supplies of household *h* in period *t* in country i, $R_{i,t} = \prod_{s=0}^{t-1} \frac{1}{1 + r_{i,s}}$ is a discount factor; $r_{i,t}$ represents the real interest rate on assets at time *s*; $t^{i,vc}$ is value added tax on consumption, $t^{i,l}$ is labour income taxes, and $K_t^{i,h}$ is the composite consumption, which is composed of sectoral consumption goods, $P_{i,t}$ is the price of composite consumption (which is based on goods'

prices), i.e. $P_{i,t} = \vartheta \prod_{i=1}^{n} \alpha_{i,g} p_{i,,g,t}^{\alpha_{i,g}}$, and $C_t^{i,h} = \prod_{i=1}^{n} C_{i,,g,t}^{\alpha_i^h}$ and the model has eleven goods, $g = 1...11$.

Industries of the economy are represented by firms that combine both capital and labour input in production and supply goods and services to the market.

$$\Pi_{j,g,t}^{y} = [((1-\delta_{i,g}^{e}) PD_{i,,g,t}^{\frac{\sigma_y - 1}{\sigma_y}} + \delta_{i,g}^{e} PE_{i,g,t}^{\frac{\sigma_y - 1}{\sigma_y}})]^{\frac{1}{\sigma_y - 1}} - \theta_j^{v} PY_{j,,g,t}^{v} - \theta_j^{d} \sum_i a_{i,j}^{d} P_{i,g,t} \quad (3)$$

where: $\Pi_{j,g,t}^{y}$ is the unit profit of activity in sector *j;* $PE_{j,g,t}$ is the export price of good *j* $PD_{j,g,t}$ is the domestic price of good *j;* $PY_{j,g,t}^{v}$ is the price of value added per unit of output in activity *j;* $\sigma_y$ is a transformation elasticity parameter ; $P_{i,g,t}$ is the price of final goods used as intermediate goods; $\delta_{j,g}^{e}$ is the share parameter for exports in total production; $\theta_{j,g}^{v}$ is the share of costs paid to labour and capital; $\theta_{j,g}^{d}$ is the cost share of domestic intermediate inputs; $a_{i,j}^{d}$ are input-output coefficients for domestic supply of intermediate goods.

**Trade arrangements**

Economies are open for trade. Exports and imports are guided by the ratio of domestic to foreign prices and balanced over years. Trade takes place between these four EU countries and the ROW and given by the standard Armington functions.

$$A_{i,g,t} = \Phi \left( \delta_{i,g}^{d} D_{i,g,t}^{\frac{\sigma_m - 1}{\sigma_m}} + \delta_{i,g}^{m} M_{i,g,t}^{\frac{\sigma_m - 1}{\sigma_m}} \right)^{\frac{\sigma_m}{\sigma_m - 1}} \quad (4)$$

where $A_{i,g,t}$ is the Armington CES aggregate of domestic supplies $D_{i,g,t}$ and import supplies $M_{i,g,t}$ for each sector, $\delta_{i,g}^{d}$ is the share of domestically produced goods, $\delta_{i,g}^{m}$ is the share of good *i* imports, $\sigma_m$ is the elasticity of substitution in the aggregate supply function, and $\Phi$ is the shift parameter of the aggregate supply function.

The value of exports balances to the value of imports .

$$\sum_{g} PE_{i,g,t} E_{i,g,t} = \sum_{g} PM_{i,g,t} M_{i,g,t} \qquad (5)$$

Households pay taxes to their governments and governments return part revenue as transfers to the poor households. They use rest of it to provide public services, education, health, security, law and order. It is given by government consumption:

$$G_{i,t} = \sum_{i=1}^{N} g_{i,g,t} \qquad (6)$$

It collects revenue from direct and indirect taxes as:

$$RV_{i,t} = \sum_{h=1}^{H} t_w^h w_{i,t} LS_t^{i,h} + \sum_{h=1}^{H} t_k^i r_t K_{i,,g,t} + \sum_{h=1}^{H} t_{i,t}^h p_{i,t} C_{i,g,t}^h \qquad (7)$$

Revenue is balanced over the model horizon:

$$\sum_{t=1}^{\infty} G_{i,t} = \sum_{t}^{\infty} \left( RV_{i,t} + \sum_{h=1}^{H} R_t^{i,h} \right) \qquad (8)$$

Optimal level of public sector balances benefits and costs from the public sector activities.

**Drivers of the Dynamic in the Economy**

Dynamics of the economy are driven by the accumulation of capital and fluctuations in labour supply because of fluctuations in the supply of labour. Capital stock evolves naturally with its initial and boundary conditions:

$$K_{i,g,t} = \left(1 - \delta_{i,g}\right) K_{i,g,t-1} + I_{i,,g,t} \,;\, K_{i,g,t} = K_{i,g,0} \quad K_{i,g,T} = \left(g_{i,g} + \delta_{i,g}\right) K_{i,g,T-1} \qquad (9)$$

Similarly there labour supply equations for each household with some transition probability between employment and unemployment

$$LS_t^{i,h} + L_t^{i,h} = \overline{L}_t^{i,h} \,;\; \overline{L}_t^{i,h} = \overline{L}_0 e^{n_i, t} \qquad (10)$$

In aggregate the link between employment, unemployment and the total labour force of the economy takes the following form: $E_{i,t} + U_{i,t} = \sum_{h=1}^{H} \overline{L}_t^{i,h}$

where $E_{i,t}$ denotes the number of total employed, $U_{i,t}$ number of unemployed out of total labour force $\sum_{h=1}^{H} \overline{L}_t^{i,h}$ . Both of these return to the steady state path in the long run.

**General Equilibrium**

Relative prices of commodities and factors of production keep adjusting until the demand and supply balance. Model is computed for reference path of 80 years ahead and it guarantees both inter-temporal and intra-temporal equilibrium. That means for each period given the vector of prices $p = (p_1, p_2, .., .., p_j, .., .., .., p_n)$, demand for commodities are expressed in terms of the price vector and the excess demand functions reflect the gap between demand and supply for each commodity $E_j(p) = X_j^d(p) - X_j^S(p)$ for j = 1,2, …….n. The general equilibrium is a price vector, $p^*$, such that $p^* \geq 0$ , $E(p^*) \leq 0$ if $E(p^*) < 0$ $p^* = 0$. The excess demand functions are single valued continuous function, bounded from below $E(p) \geq b$ for all $p$ and it is homogenous of degree zero in all prices $E(\alpha \cdot p) = E(p)$ for all $\alpha$ ; only relative price matter and satisfies the Walras' law; $p.E(p) = \sum_{i=1}^{n} p_i E_i(p) = 0$ for all $p \geq 0$.

Analysis presented here go beyond the comparative static structure contained in Bhattatai and Whalley (1999, 2003, 2006), Abrego and Whalley (2000) Edward and Whalley (2007) and Bhattarai (2001) and build on Bhattarai (1999, 2007a, 2007b, 2007c).

# Technical Appendix 2
# Benchmarking Procedure

Dynamics of this model are driven by growth of capital and labour. Labour growth rates are assumed exogenous. Share parameters in consumption and production are calibrated using the benchmark quantities. Inter and intra temporal elasticities of substitution in consumption and among skill categories labour and between labour and capital in production. Calibration of capital accumulation process is crucial in solving the model.

There are essentially five steps involved in calibration of this dynamic model. The first step relates to forming a relation between the price of investment good at period *t* in country *i*, $P_{i,t}$ and the price of capital in period *t+1*, $P^k_{i,t+1}$. It also needs specifying a link between prices of capital stock at periods *t* and *t+1*, $P^k_{i,t}$ and $P^k_{i,t+1}$, with due account of the rental on capital and the depreciation rate. For instance, one unit of investment made using one unit of output in period *t* produces one unit of capital stock in period *t+1*. This implies, $P_{i,t} = P^k_{i,t+1}$, where $P_{i,t}$ is the price of one output in period *t* and $P^k_{i,t+1}$ is the *t* period price of one unit of capital in period *t+1*.

Capital depreciates at the rate of $\delta_i$. One unit of capital at the beginning of period *t* earns a rental $R^t_{i,t}$ and delivers *(1-*$\delta_i$ *)* units of capital at the end of period t (or at the start of the *t+1* period), $(1-\delta_i)P^k_{i,t+1}$. Here $R^t_{i,t}$ is also measured in term of $P^K_{i,t+1}$ or $P_{i,t}$.We therefore must have:

$$P^k_{i,t} = R^t_{i,t} + (1-\delta_i)P^k_{i,t+1} \qquad (11)$$

In a perfect foresight world price of capital in period *t* really reflects the sum of discounted rental over time.

The second step of calibration involves setting up a link of the rental rate with the benchmark interest rate and the depreciation. The rental covers depreciation and interest payment for each unit of investment. When rental is paid at the end of the period

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

where *r* is the benchmark real rate of interest.

Thirdly step of calibration involves forming relation between the future and the current price of capital. Use equation (6) and (7) together to get

$$\frac{P_{i,t+1}^{k}}{P_{i,t}^{k}} = \frac{1}{1+r_i} \approx 1-\delta_i . \qquad (13)$$

This means that the ratio of prices of the capital at period *t* and *t+1* equals to the market discount factor in the model, which is $(1-\delta)$.

The fourth step of calibration involves setting up equilibrium relation between capital earning (value added from capital) and the cost of capital. We compute values for sectoral capital stocks from sectoral capital earnings in the base year. If capital income in country *i* sector *g* in the base year is $\overline{V}_{i,g}$, we can write $\overline{V}_{i,g} = R_{i,g}K_{i,g}$. Thus investment per sector is tied to earnings per sector. Since the return to capital must be sufficient to cover interest and depreciation, we can also write

$$\overline{V}_{i,g} = (r_i + \delta_i)P_{i,t+1}^{k}K_{i,g}, \text{ or } \quad K_{i,g} = \frac{\overline{V}_{i,g}}{(r_i + \delta_i)} \quad \text{Since } P_{i,t} = P_{i,t+1}^{k} = 1 \qquad (14)$$

The fifth step of calibration involves setting up relation between the investment and capital earning on the balanced growth path. Investment should be enough to provide for growth and depreciation, $I_{i,g} = (g_i + \delta_i)K_{i,g}$, which together with (9) implies

$$I_{i,g} = \frac{(g_i + \delta_i)}{(r_i + \delta_i)}\overline{V}_{i,g} \qquad (15)$$

The balance between investment and earnings from capital is restored here by adjustment in the growth rate $g_i$ that responds to changes in the marginal productivity of capital associated to change in investment. Readjustment of capital stock and investment continues until this growth rate and the benchmark interest rates become equal.

If the growth rate in sector $g$ is larger than the benchmark interest rate then more investment will be drawn to that sector leading to an increase in the capital stock in that sector. By the process of diminishing return to capital more investment eventually will lower growth rate of that sector eliminating the excess returns that attracted investment in the beginning. In the benchmark equilibrium, all reference quantities grow at the rate of labour force growth, $g$, and reference prices are discounted on the basis of the benchmark rate of return as given by equation (8) above.

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