

Dynamic Multi- household General Economic Models for Policy Simulations in EU

For France, Germany, Spain and UK

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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 in 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, generates more efficiency, incentives and 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, 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, Rutherford (1987) study comparative advantage under Ricardo-Heckscher-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 transfers provided by surplus generated by debt reduction would benefit future poor, thus intergenerational equity is likely to pose a threat to the fiscal consolidation that is less likely to occur. Keuschnigg, Kohler, Casella, 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 consider 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. Piazzolo (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 be different when estimated with bilateral rather than multilateral data. Wren-Lewis, Darby, Ireland, 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. Despite¹ 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 demand for goods and services are derived from the preferences subject to life time budget constraints 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

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 JWhalley (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.

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 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 poorest in terms of income and H10 the richest. 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 were more important than indirect such as value added. 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 demand for products by households equal supply of products by firms and saving by households equal investment by firms. The Pareto optimality is achieved in each period – there exists 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

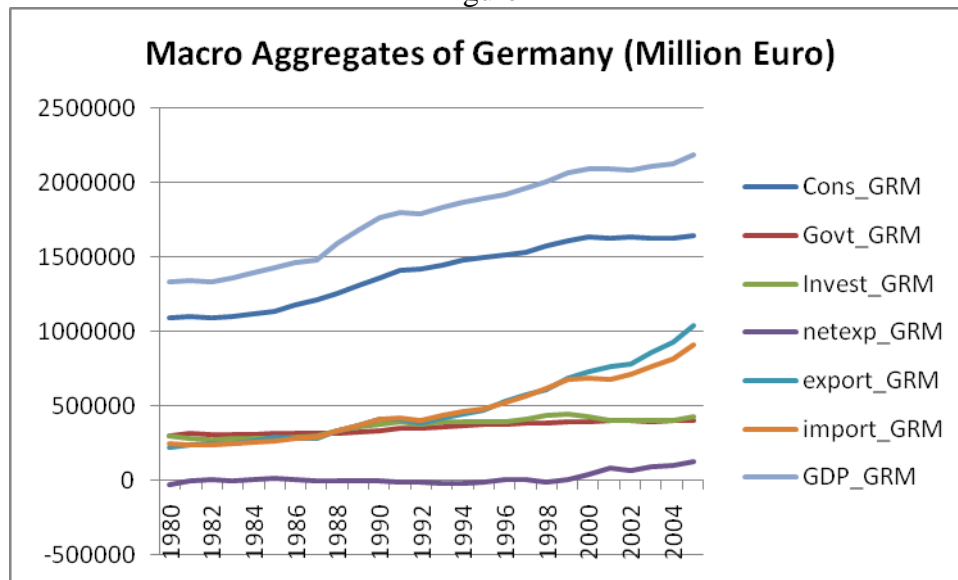
This section briefly presents major challenges and constraints faced by each of the four major economies contained in this study with macro trends and micro consistent data required to benchmark the economy.

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 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

a 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

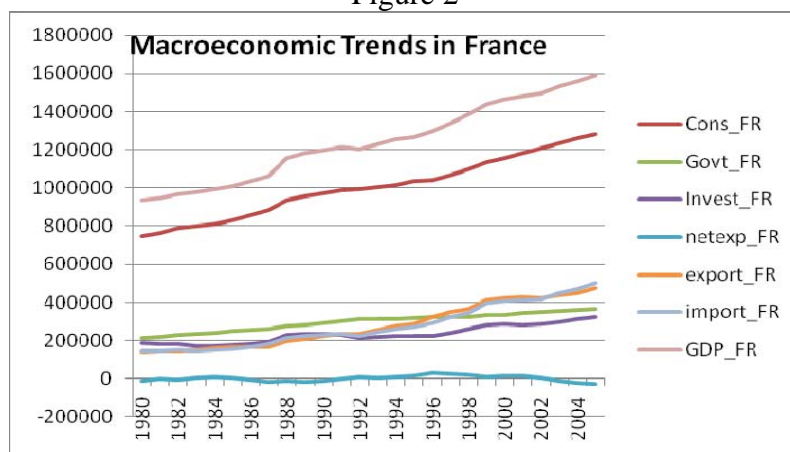
Data Source: OECD, DSTO/DOC(2006)8 World Bank data at www.mimas.ac.uk for income and Table 2.7 of WDI for consumption Share.

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 French GDP. Proportionately to the size of GDP the wage income 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

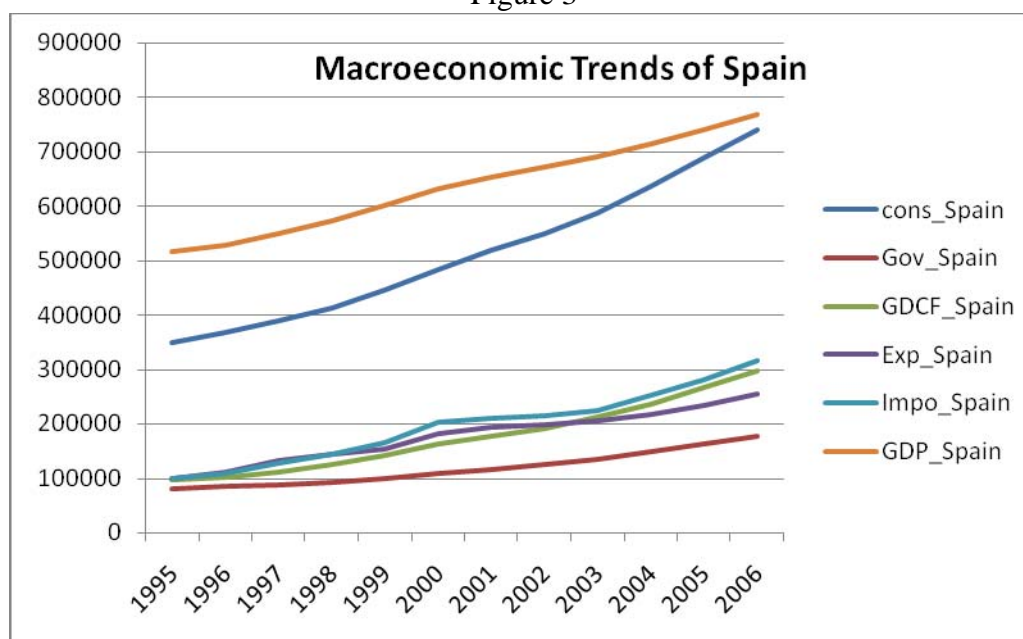
	h1	h2	h3	h4	h5	h6	h7	h8	h9	h10
Incshare	0.0275	0.0443	0.0631	0.0631	0.0860	0.0860	0.1140	0.1140	0.1512	0.2509
Consshare	0.0280	0.0440	0.0630	0.0630	0.0860	0.0860	0.1140	0.1140	0.1510	0.2510
Capital	13230.77	21313.57	30358.61	30358.61	41352.18	41352.18	54847.57	54847.57	72745.19	120712.76
Wages	20298.49	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 turmoil 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%) relative to 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

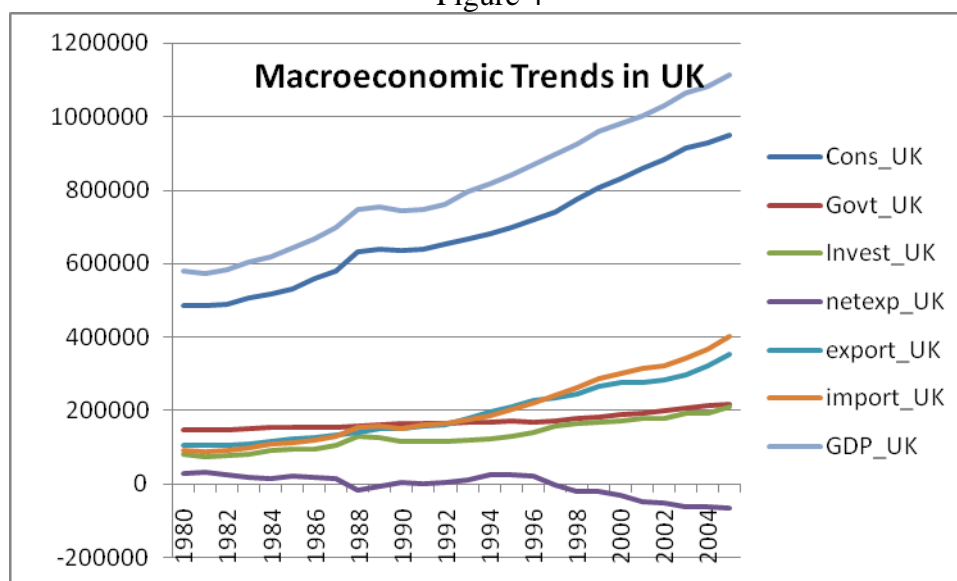
	h1	h2	h3	h4	h5	h6	h7	h8	h9	h10
Incshare	0.0257	0.0440	0.0605	0.0605	0.0822	0.0822	0.1126	0.1126	0.1539	0.2661
Conssshare	0.0260	0.0440	0.0605	0.0605	0.0820	0.0820	0.1125	0.1125	0.1540	0.2660
intr	6217.9	10645.4	14625.3	14625.3	19875.4	19875.4	27230.4	27230.4	37234.7	64380.4
wage	7706.8	13194.6	18127.6	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. 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



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 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)	
Elasticity of substitution in public consumption	1.5

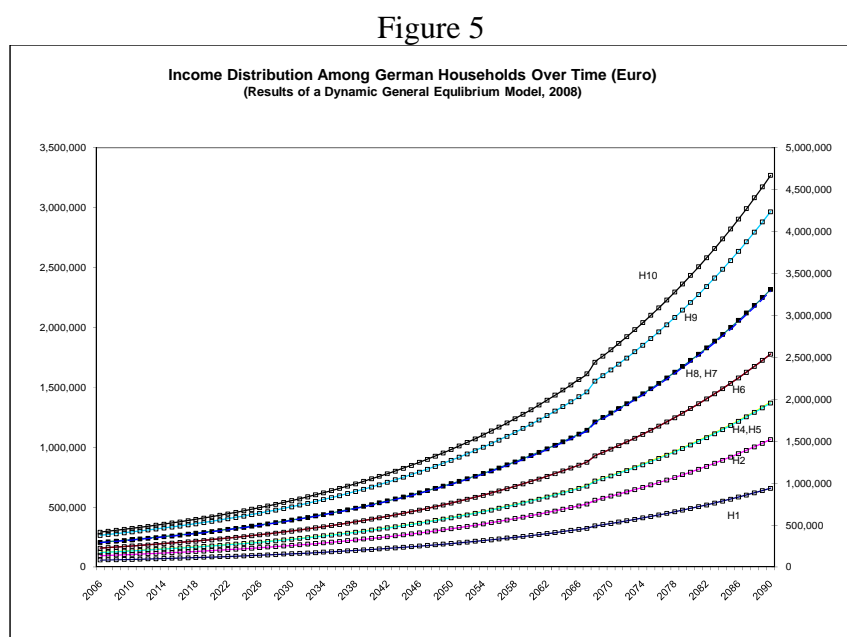
Table 6
Structure of Taxes on Inputs

	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.



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

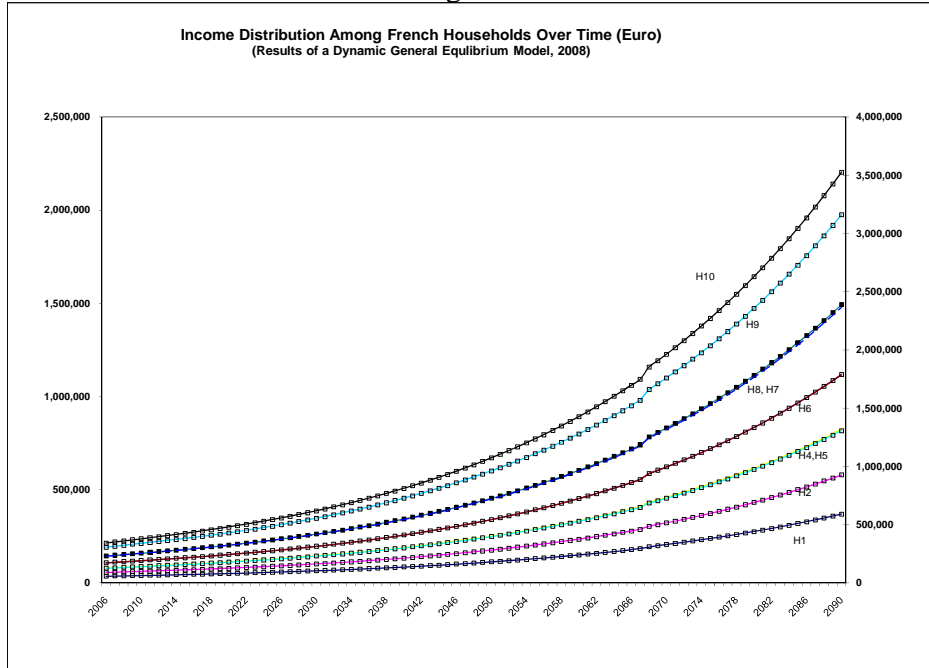


Figure 7

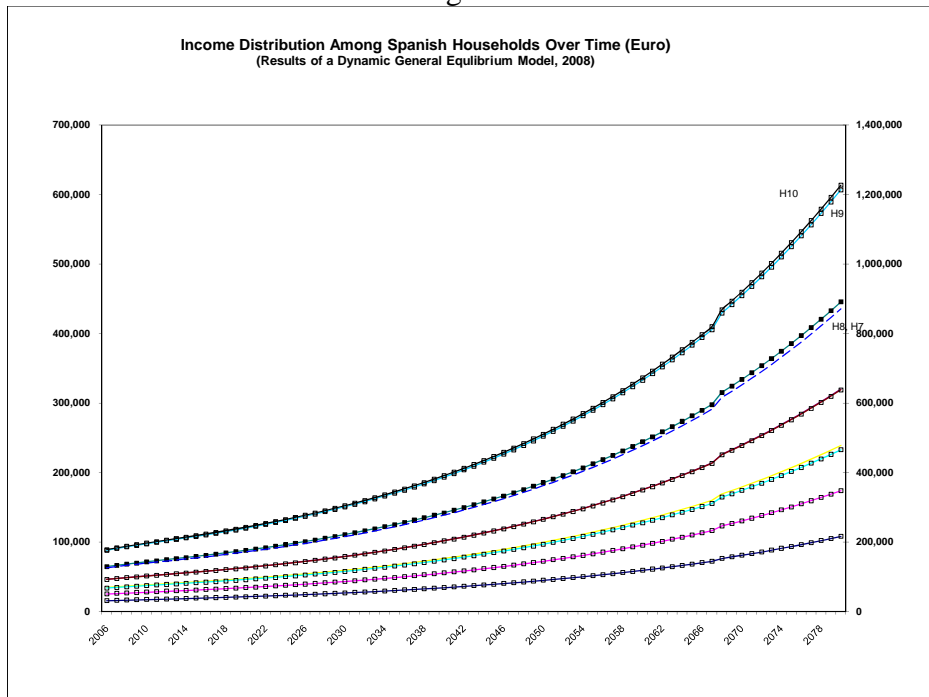
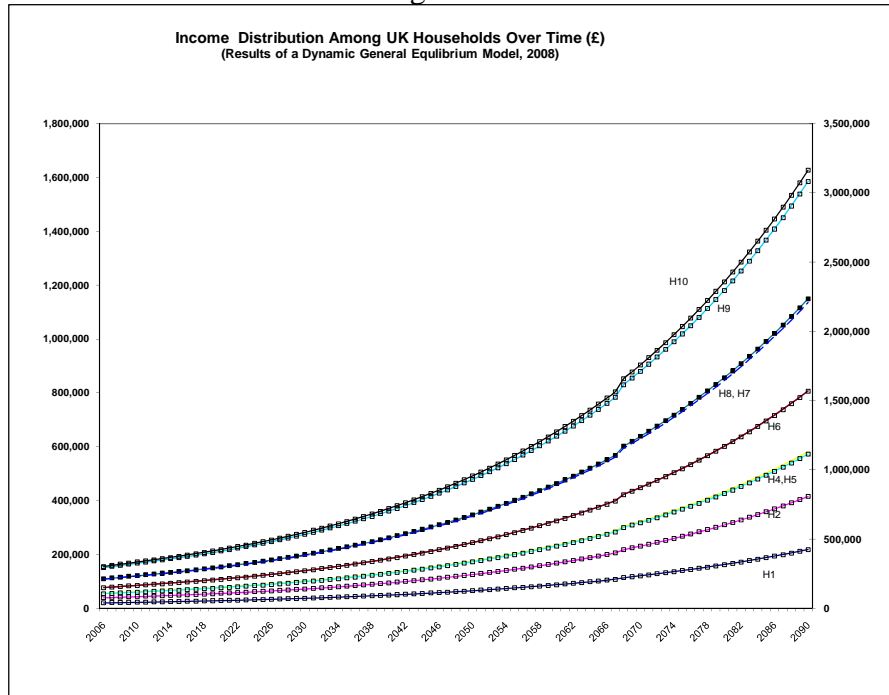


Figure 8



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 $i = 1 \dots 4$ countries and $h = 1 \dots 10$ 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.

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

Subject to

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

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. $P_{i,t} = \mathcal{G} \prod_{i=1}^n \alpha_{i,g} p_{i,g,t}^{\alpha_{i,g}}$, and

$C_t^{i,h} = \prod_{i=1}^n C_{i,g,t}^{\alpha_{i,g}^h}$ and the model has eleven goods, $g = 1 \dots 11$.

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 ; σ_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, σ_m is the elasticity of substitution in the aggregate supply function, and Φ is the shift parameter of the aggregate supply function.

The value of exports balances to the value of imports .

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

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:

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

It collects revenue from direct and indirect taxes as:

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

Revenue is balanced over the model horizon:

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

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:

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

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

$$LS_t^{i,h} + L_t^{i,h} = \bar{L}_t^{i,h}; \bar{L}_t^{i,h} = \bar{L}_0 e^{n_{i,t}} \quad (10)$$

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

where $E_{i,t}$ denotes the number of total employed, $U_{i,t}$ number of unemployed out of total labour force $\sum_{h=1}^H \bar{L}_t^{i,h}$. 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 $p = (p_1, p_2, \dots, p_j, \dots, p_n)$, 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 $j = 1, 2, \dots, n$. 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 α ; only relative price matter and satisfies the Walras' law; $p \cdot E(p) = \sum_{i=1}^n p_i E_i(p) = 0$ 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 $t+1$, $P_{i,t+1}^k$. It also needs specifying a link between prices of capital stock at periods t and $t+1$, $P_{i,t}^k$ and $P_{i,t+1}^k$, 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, $P_{i,t} = P_{i,t+1}^k$, where $P_{i,t}$ is the price of one output in period t and $P_{i,t+1}^k$ is the t period price of one unit of capital in period $t+1$.

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

$$P_{i,t}^k = R_{i,t}^t + (1 - \delta_i)P_{i,t+1}^k \quad (11)$$

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

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

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

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

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 $\bar{V}_{i,g}$, we can write $\bar{V}_{i,g} = R_{i,g} K_{i,g}$. 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

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

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

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

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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Terms of Reference for Research

General Economic Models for Policy Simulations: A Report on the Dynamic General Equilibrium Model of the European Economies

The Sixth Framework Programme on Citizens and Governance in A Knowledge Based Society aimed

- a) to investigate economic and social mechanism that is producing polarisation and inequality within EU and neighbouring countries;
- b) to evaluate the effects of inequality in societies and its relation with economic performance and social integration;
- c) to identify actual and possible policies at national, EU and global levels

Work Package 5 aims to fulfil these objectives by developing General Economic Models for at least four EU Economies.

Description of work

“Computable general equilibrium techniques will be used to decompose changes in inequality in several European countries since the 1970s (in terms of relative wages and unemployment rates) according to their possible causes, including technological change, trade with low wage economies, an increase in the skill level of the workforce.

Up to four countries will be selected for this CGE based analysis in part by drawing on the research findings of other work packages, especially WP2 (Technology human capital and inequality) and WP3 (Trade, FDI, Finance and inequality). Germany and UK will be definitely included because of their contrasting labour market institutions and policies. The CGE model will be based on data from secondary sources (input-output tables, national accounts and fiscal accounts).

Task 5.1 Constructing the basic CGE models for selected European countries

Task 5.2 Decomposing the changes in inequality according to their major causes. For each selected country, the respective CGE model will be calibrated at two points in time. Simulations will then be run to reveal the impact of changes in the exogenous variables and calibrated model parameters

Task 5.3 Dynamic extension and policy simulations: while the analyses in Task 5.2 are of a comparative static nature (comparing an economy at two points in time), dynamic version of the CGE models will be used to simulated the impact of alternative policy strategies on inequality.”

This report will explain the structure of the dynamic general equilibrium models for UK, Germany, France and Spain setting appropriate background for extending this research programme for European economies.