This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

Document Details

Authors	CE
Creation Date	01/02/2018
Date of Last Revision	27/09/2018
Version	V1.0
Description	Description of baseline case to be used in the models

Version History

Version	**Updated By**	**Date**	**Changes / Comments**
Draft version	Malin Berg von Linde / Stijn Van Hummelen	27/09/2018	
V1.0	Hector Pollitt / Stijn Van Hummelen	30/09/2018	To be submitted

Project Involvement

Project Director	Olga Ivanova
Project Manager	Iason Diafas
WP Manager	Hector Pollitt
Project Leads	PBL

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

1 Importance of the baseline

1.1 Introduction

The objective of MONROE is to analyse how research and innovation (R&I) and related policies affect the European economy, at macro, regional and sectoral level, with a set of models. The modelling in the project provides an assessment of how an intervention affects the economy through a scenario-based approach. Analysis of the impacts in the scenarios requires a comparison against what the outcomes would have been in the absence of intervention. This information is found in the baseline, and the differences in outcomes between the results in the baseline and the results in the scenarios are attributed to the policies that are assessed.

In summary, the baseline refers to measurements of key conditions, or indicators, from which change and impacts can be assessed. Baseline data vary depending on the type of analysis that is performed and the type of model that is used. Because the MONROE project includes assessments by a set of quite different models, more than one baseline is required. More generally, however, the baseline includes data on both the inputs to the modelling exercise, and the things that we want to assess. In MONROE, the baseline data therefore include demographic indicators, labour market information, labour productivity and GDP growth, energy consumption and emissions, and elements relevant for assessing R&I policies, such as the number of educated people, institutional settings, the degree of globalisation, and local versus global knowledge markets. Finally, the baseline must also include information on levels of R&I, for example R&D expenditure and the policies that promote it.

1.1.1 Interpreting 'business as usual'

Moving away from the technicalities of the baseline, it makes sense to formalise how the baseline should be interpreted. The baseline is a 'business as usual' (BAU) case and represents what would happen in the scenarios without the assessed policy.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

This does not mean that new or continued policy cannot be included in the baseline scenarios. However, it is important that the baseline does not introduce a bias in the indicators against which policy is evaluated, and important variables are therefore commonly calibrated to published projections.

1.1.2 Endogenous vs. exogenous variables

It is further useful to distinguish between exogenous and endogenous variables in the different models. Exogenous variables are not explained within the model, but instead taken as inputs to make the model to work (they are determined 'outside the system'). They are often scenario specific and differ between areas and type of analysis undertaken. Endogenous variables on the other hand are explained by the model equations, either stochastic equations or identities, and produced by the model as it solves.

In forming a baseline case, it is clear that the exogenous variables must be set to pre-agreed values. In addition, some of the endogenous variables produced by the models are adjusted to be consistent with published values. In Section 2 and 3 of this report, we provide a non-exhaustive overview[1] of the data sources for the exogenous variables and the endogenous variables to which the Monroe models calibrate in the baseline. In Section 6 of this report we describe how the different models do this.

1.2 Structure of the report

Ultimately, the baseline provides a critical reference point for assessing policy impacts. This report describes the methodology through which the MONROE baselines are constructed, their associated assumptions, a summary of the resulting baseline characteristics and a technical section of how MONROE's different models calibrate to published projections for the baseline indicators. The final section provides a few concluding remarks.

[1] The baseline scenarios adopted by each of the models can include additional endogenous variables not presented in this report.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

2 Baseline sources and methodologies

This section presents the baseline data sources for E3ME, GEM-E3, PACE and EU-EMS. Table 1 presents which published sources that are used for each of the models.

Table 1: Baseline sources

Sources	EU-EMS	PACE	E3ME	GEM-E3
The Ageing Report/Eurostat projections	x	x	x	x
EU Reference Scenario		x	x	x
UN demographic projections		x	x	x
GTAP-9		x		
IEA World Energy Outlook		x	x	x
EU-KLEMS database	x			
IIASA education projections	x			
SSP Database**				x
IMF World Economic Outlook**°				x
Economic Forecast, EC*°			x	x

*Used for EU-countries, **Used for non EU-countries, °Short term projections.

The models have different geographical coverage as well as sectoral scope, and therefore, use different source data depending on need of disaggregation. For the EU Member States, there are however significant overlaps. These baseline sources will be described in the following sub-sections, including assumptions and methodologies through which the source data were produced. The data are grouped into the following categories for presentation:

- Demography and migration
- Labour markets and GDP
- Energy and emissions
- Research and innovation

2.1 Demography and migration

E3ME, GEM-E3, PACE and EU-EMS use projections from the Ageing Report and Eurostat for baseline demographic and migration trends for the EU. **EU-EMS** further relies on Eurostat projection of annual population at the level of NUTS2 regions by age cohort and gender for the period until 2050. The data files were received from Eurostat upon a special request for the use in the MONROE project.

The Ageing Report's projections are constructed using a convergence methodology approach, which means that key demographic determinants of the Member States are assumed to converge in the very long run. In the projections, fertility rates, mortality rates, and the level of net migration are the considered key determinants. Practically, the year of 2060 is set for convergence. The advantage of this is that it is possible to consider recent trends and developments in the beginning of the period, while assuming convergence as a key demographic driver (European Commission, 2015).

For fertility and mortality, it is assumed that the rates converge to the rates of the Member State forerunners. For fertility, the forerunners are Ireland, France and Sweden. Since 1960, the life expectancy at birth has increased significantly in all Member States. While there is no consensus among scientists regarding potential maximum increase of life expectancy, the Ageing Report assumes that gains in life expectancy at birth will slow down compared to historical trends (European Commission, 2014).

Migration is not as straightforward. Since the 1950's, European countries have seen a gradual increase in the net inflow of migrants. In the beginning of the 2000's, net migration flows to the EU countries spiked, reaching 1.8 million people in 2003, and staying above 1.5 million until the financial and economic crisis. In 2009-2011 net migration dropped to 700,000 annually, only to again reach 1.7 million people in 2013. In addition to variation over time, there is variation between Member States due to different national economic and political conditions. Therefore, there has been no attempt of identifying a common data generating process for migration across the EU. Instead, an ARIMA model of optimal automatic selection has been specified for each country. Within this framework, there is still an assumption about convergence in the very long run, of net migration to reach zero in 2060. Intermediate values are obtained using double linear interpolation between the last observed year and zero in the convergence year. Zero net migration does not infer zero migration, only equal levels of immigration and emigration (European Commission, 2015).

2.1.1 Global regions

This project has received funding from the European Union's Horizon 2020 research and innovation programme
under grant agreement No 727114

For regions outside of Europe, **E3ME, PACE and GEM-E3** use UN population projection from the "World Population Prospects: The 2017 Revision" report is used. Like the Eurostat report, demographic features of population ageing, fertility and life expectancy are accounted for.

Global fertility rates have declined in nearly all regions of the world outside of Europe, while life expectancy have increased substantially, leading to new demographic structures with a much older population. As for migration, a large continued movement of people between regions is expected, often from low- and middle-income countries toward high-income countries (UN, 2017).

2.2 Labour markets and GDP

For labour productivity and GDP growth, **E3ME, GEM-E3 and EU-EMS** use the EU Ageing Report and Eurostat projections for EU Member States.

2.2.1 The labour force

There are large labour force differences between EU Member States, and to make realistic projections a few stylised facts need to be considered:

- Participation rates of male workers aged 25-54 remains the highest among all population segments, at almost 90%. The participation rates of men aged 55-64, which have declined steadily over the last 25 years, are increasing again due to pension reforms and raising the statutory retirement age.
- Female participation rates have steadily increased over the past 25 years, reflecting societal trends as well as pension reforms.
- Participation rates of young people, aged 15-24, have declined due to higher educational attainment driven partly by unfavourable cyclical developments (European Commission, 2015).

Thus, the main drivers of the projected change in the total participation rate are changes in the labour force participation of prime age women, older workers (especially women), and to a lesser extent, young people.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

A cohort simulation model (CSM) is then used to project participation rates, which has the benefit of being able to account for expected effects of legislated pension reforms, including future policies phased in gradually. The methodology is based on the calculation of the average probability of labour force entry and exit observed over the last ten years. Unemployment rates are further assumed to converge to non-accelerating wage rate of unemployment (NAWRU) rates by 2018, corresponding to the closure of the output gap (European Commission, 2015).

EU-EMS makes use of the methodology proposed by Loichinger (2015) (and being adopted by Eurostat) for the projections of the labour force for NUTS2 regions. The methodology is based on a shift-share approach and has been used to forecast labour force by two levels of education, tertiary education or not, in EU26 countries for the period until 2053. The proposed approach makes sense since the level of education is strongly positively correlated with the labour participation rates for both males and females (REFERENCE). In the baseline case, labour participation rates are modelled towards a given benchmark distribution. The benchmark distribution is seen a desired outcome that can be achieved given the right governmental policies. We use the target distribution of labour participation rates observed on Sweden in 2008 (Labour Force Survey of Eurostat) as the benchmark for other European countries and regions in 2050. Since the difference between males and females in Sweden is very low this approach leads to reduction in the gender gap over time.

2.2.2 Labour productivity and GDP

In the Ageing Report, potential GDP growth is explained by a combination of labour productivity and labour input. Up to 2030, labour productivity growth in the EU is assumed to be largely explained by total factor productivity (TFP) growth in the Member States with larger catching up potential. The rate of growth is assumed to remain stable over the long term, but to be lower than previous decades. A convergence to a TFP growth rate of 1% annually is assumed (European Commission, 2015). This is used by **E3ME, GEM-E3 and PACE**.

For **EU-EMS**, the regional economic growth by NUTS2 regions is estimated using a combination of SCGE modelling with the econometrically estimated predictions of labour

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

participation rates and labour supply, sector specific changes in TFP driven by the combination of knowledge creation and knowledge adoption with changes in preferences of households for particular goods and services we are able to predict the development of GDP at NUTS2 regional level for the period 2015-2050 in five year steps.

2.3 Energy and emissions

For trends related to energy and emissions, **E3ME, GEM-E3 and PACE** use the EU 2016 Reference scenario, commonly referred to as the PRIMES scenario for the baseline case. The PRIMES scenario is consistent with the Ageing Report for long term population and GDP growth rates, while short- and medium-term GDP growth projections were taken from DG ECFIN. The PRIMES scenario focuses on EU's energy system, transport, and greenhouse gas (GHG) emission projections, and includes various interactions among policies in these sectors, with projections for each EU Member State individually. The projections are presented from 2015 onwards in five-year steps until 2050 (European Commission, 2016).

It is assumed that the legal GHG and renewable energy sources (RES) targets for 2020 are achieved and that the policies agreed at EU and Member State level until December 2014 are implemented (European Commission, 2016).

Several models are used to produce the PRIMES scenario: the PRIMES model for transport, energy, and CO2 emissions; the GAINS model for non-CO2 emissions; the GLOBIOM-G4M model for land use and land-use change and forestry (LULUCF) emissions projections; the GEM-E3 macroeconomic model for value added projections by branch of activity; the PROMETHEUS global energy model for projections of world energy prices; and the CAPRI model for agricultural activity projections. These interlinked models combine technical and economic methodologies, following an approach based in microeconomics, to solve for a price driven market equilibrium which produces detailed projections per sector and country (European Commission, 2016).

It is possible to analyse emissions reductions, energy efficiency, and renewable energy targets simultaneously. The scenario is consistent with harmonised EU assumptions, but

This project has received funding from the European Union's Horizon 2020 research and innovation programme
under grant agreement No 727114

also benefits from interactions with Member State experts at various stages of the process (European Commission, 2016).

2.4 Research and innovation

The Ageing Report provides information on governmental spending on education for the EU. Historically, governmental expenditures on education have largely reflected demographic developments of the country. In the projections of government spending on education, no policy change and a constant student-teacher ratio is assumed. As the methodology is stylised it does not capture country specific elements of education systems, however, while education systems are different between countries, features of compulsory and non-compulsory education are alike, such as education starting between ages 5-7 and ending between the ages 13-16. The methodology accounts for enrolment rates by age and education level, and expenditure categories by education level and type (European Commission, 2015). The levels of spending on education is used by **E3ME**.

For R&I, published projections are less common, therefore, baseline R&I intensities as projections are provided for by country and sector by PBL and **EU-EMS**. The database used for the econometric analysis of these is the EU-KLEMS database which covers 28 countries of which most of them are OECD countries until the year 2015. Following standard practices, the measure for the RD intensity is based on private R&D expenditures as a share of value added - defined as the output of each industry excluding intermediate goods - in constant prices.

The following equation is used to model R&D intensity, where PBL assumes that R&D decision follow an AR(1) process with a constant term as follows:

$$RD_{cst} = a * RD_{cst-1} + c + e_{cst} \qquad (1)$$

where a and c are the parameters to be estimated and e_{cst} is the error term. This specification assumes that current R&D decisions are affected by past R&D decisions with the parameter a to determine their persistence over time. The inclusion of the constant term c determines the average R&D expenditures around which all R&D decisions deviate in each period. Based on this equation PBL projects the development of R&D intensity across sectors in the future, and calculates the expected long-run values for research intensity. For example, under standard stationarity assumptions, calculating the long-run first moment of the variable R&D in equation (1), we are able to uncover the expected value to which RD investment decision are expected to evolve in the long-run.

In addition to **EU-EMS**, the R&I intensities are used by **E3ME, GEM-E3 and PACE.**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

3 Important indicators

This section presents the most important trends and developments of relevant indicators, presented in the same grouping as the section 2 of this report.

3.1 Demography and migration

Due to the three main drivers of the EU population (fertility, life expectancy, and migration), the age structure and size will change significantly in the coming decades. The total fertility rate in the EU is projected to rise to 1.7 in 2030 and further to 1.8 in 2050. While increasing, levels are well below the natural replacement rate of 2.1 (European Commission, 2015).

Simultaneously, the projections show a large and sustained increase in life expectancy. For women, life expectancy at birth will increase to 88.1 in 2050. For men, life expectancy at birth will increase to 83.6 over the same time period (European Commission, 2015).

The total population increase of the EU is, however, largely explained by the projected inward migration flows. Net migration inflow for the EU is projected to decline from 1.9 million people in 2015 to 1.1 million in 2020 and 1.05 million people in 2050.

As a result, the overall size of the EU's population is projected to be slightly larger but much older in 2050. From 508 million people in 2015, it increases to 528 million people by 2050. Table 2 presents the demographic indicators for the EU.

Table 2: EU Demographic indicators

Demographic indicators	2020	2030	2040	2050
Fertility rate	1.6	1.7	1.7	1.8
Life expectancy at birth				
males	79.1	80.7	82.2	83.6
females	84.3	85.6	86.9	88.1
Life expectancy at 65				
males	18.6	19.7	20.7	21.6
females	22.0	23.0	24.0	24.9
Net migration (thousand)	1127.1	1157.2	1154.3	1053.3

This project has received funding from the European Union's Horizon 2020 research and innovation programme
under grant agreement No 727114

Net migration (% of population)	0.2	0.2	0.2	0.2
Population (million)	516.1	524.1	528.5	528.4
Children population (0-14) (% of total)	15.4	14.9	14.7	14.9
Prime age population (25-54) (% of total)	39.9	36.8	35.2	34.4
Working age population (15-64) (% of total)	64.0	61.0	58.2	56.6
Elderly population (65 and over) (% of total)	20.5	24.1	27.1	28.5
Very elderly population (80 and over) (% of total)	5.9	7.3	9.2	11.2

Source: The 2018 Ageing Report: Statistical annex and tables

3.1.2 Global developments

Population ageing is not a phenomenon restricted to the EU, but something that is observed in other parts of the world as well. Africa's population is projected to increase at the fastest rate, amounting to 28% of the world population in 2060. Asia's share of the global population declines slightly, but still accounts for over 50% in 2050. The decline is particularly evident for China, where the world population share is projected to fall from 19.6% in 2010 to 13.2% in 2060. The population of the European continent will become relatively smaller (European Commission, 2015).

The UN population projections find that China and India remain the most populous countries, but that the population of India is to surpass that of China in 2025. In the rapidly growing African countries, Nigeria grows the most and is expected to become the third largest country in the world before 2050. Generally, most of the global increase until 2050 is attributable to population growth in nine countries: India, Nigeria, the Democratic Republic of the Congo, Pakistan, Ethiopia, the United Republic of Tanzania, the United States of America, Uganda and Indonesia.

The largest increase in life expectancy gains were found in Africa, and the gap in life expectancy at birth between the least developed countries (LDC) and other developing countries is narrowing. Globally, the number of persons older than 60 years of age is expected to have doubled by 2050, and the number of persons older than 80 years of age is expected to have tripled (UN, 2017).

3.2 Labour markets and GDP

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

The demographic developments are reflected in labour markets. The period until 2022 is characterised by rising employment rates, lower unemployment levels, higher female labour market participation, and people staying longer at work before retiring. The increase of labour is dampened slightly as the baby-boom generation retires. From 2023 on, however, the ageing effect on the labour market dominates and both the working-age population share and the number of people employed start to fall over the remainder of the period (European Commission, 2015).

3.2.1 The labour force

The EU labour market participation rate of older people, aged 55-74, is estimated to increase by about four percentage points (pp) by 2020, by ten pp by 2040, and by eleven pp by 2060 due to the projected impact of pension reforms. The increase in total participation rates is, however, primarily driven by a large increase in the participation rate of women aged 25-54 (European Commission, 2015).

The EU's total labour supply, age group 20-64, is projected to remain stable until 2023, after which it is expected to decline steadily until 2050. The total EU employment rate, for people aged 20-64, is projected to increase to 78.4% in 2020 and to 80.4% in 2050. The share of older workers in total employment will rise about one third, changing the age structure of employment (European Commission, 2015).

Table 3 presents important labour force indicators.

Table 3: EU labour force indicators

The labour force	2020	2030	2040	2050
Working age population (15-64) (thousands)	330,437.8	319,688.1	307,469.7	299,167.7
Population growth (working age:15-64)	-0.2	-0.5	-0.3	-0.2
Population (20-64) (in thousands)	303,769.5	292,646.3	280,639.6	272,630.3
Population growth (20-64)	-0.2	-0.4	-0.3	-0.2
Labour force 15-64 (thousands)	243,565.8	238,192.6	230,313.4	225,010.5
Labour force 20-64 (thousands)	238,111.2	232,548.2	224,541.6	219,279.1
Participation rate (20-64)	78.4	79.5	80.0	80.4
Participation rate (15-64)	73.7	74.5	74.9	75.2

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

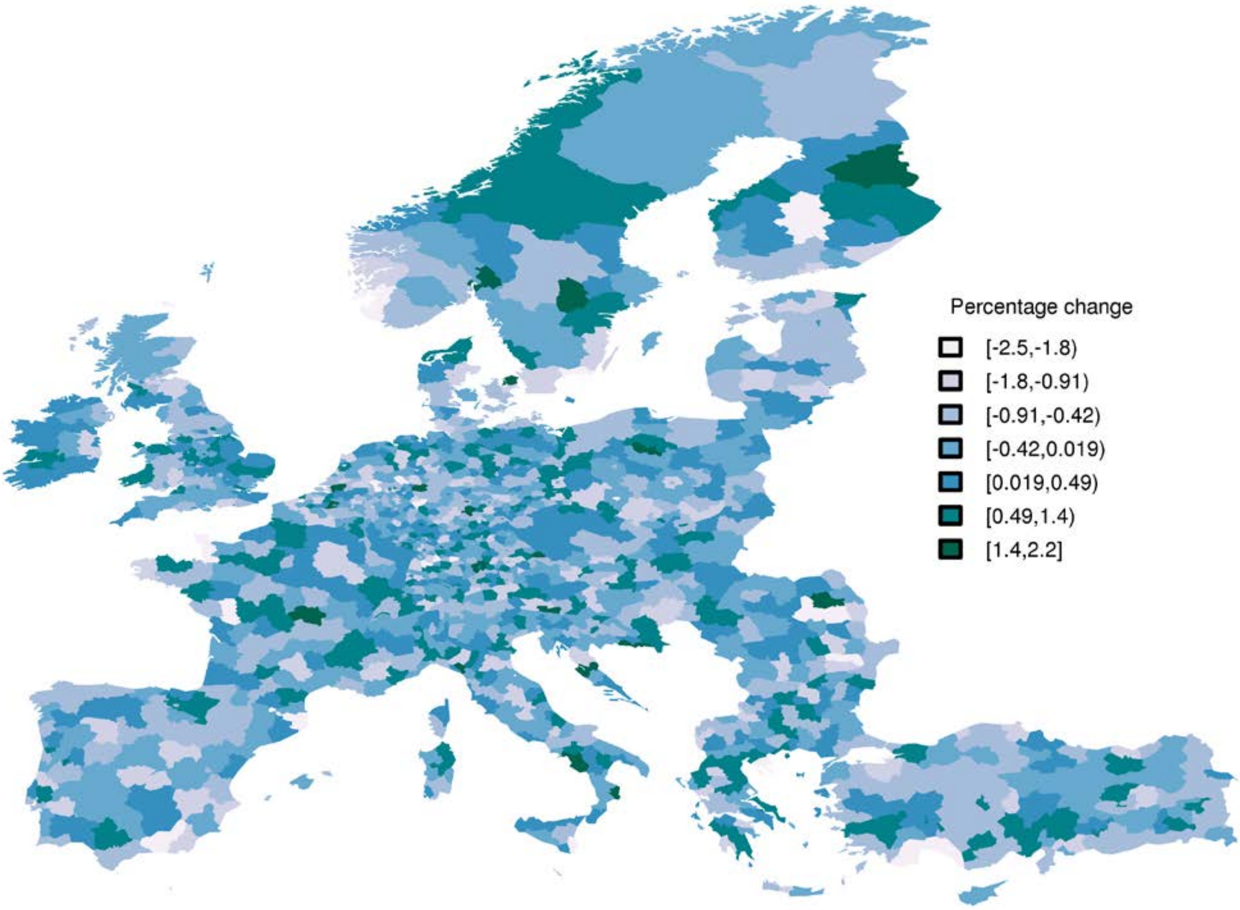
Participation per age group				
young (15-24)	42.3	42.4	42.8	42.9
prime-age (25-54)	85.9	86.2	86.5	86.6
older (55-64)	62.4	68.0	69.2	70.1
Participation rate (20-64) - FEMALES	72.7	74.8	75.8	76.4
Participation rate (15-64) - FEMALES	68.5	70.3	71.1	71.5
Participation per age group (FEMALES)				
young (15-24)	39.8	39.9	40.3	40.5
prime-age (25-54)	80.5	81.7	82.2	82.4
older (55-64)	55.7	63.2	65.2	66.7
Participation rate (20-64) - MALES	84.0	84.1	84.1	84.3
Participation rate (15-64) - MALES	78.9	78.7	78.6	78.8
Participation per age group (MALES)				
young (15-24)	44.6	44.7	45.1	45.2
prime-age (25-54)	91.3	90.7	90.6	90.7
older (55-64)	69.3	73.0	73.2	73.6
Average effective exit age	64.2	64.9	65.1	65.4
Men	64.4	65.1	65.3	65.6
Women	63.9	64.6	65.0	65.2
Employment rate (15-64)	68.1	69.0	69.7	70.4
Employment rate (20-64)	72.7	73.9	74.8	75.5
Employment rate (15-74)	59.8	60.1	60.5	61.4
Unemployment rate (15-64)	7.6	7.4	6.9	6.5
Unemployment rate (20-64)	7.3	7.0	6.6	6.1
Unemployment rate (15-74)	7.5	7.2	6.6	6.2
Employment (20-64) (in millions)	220.7	216.2	209.8	205.9
Employment (15-64) (in millions)	225.0	220.6	214.4	210.5
share of young (15-24)	0.1	0.1	0.1	0.1
share of prime-age (25-54)	0.7	0.7	0.7	0.7
share of older (55-64)	0.2	0.2	0.2	0.2

Source: The 2018 Ageing Report: Statistical annex and tables

Figure 1 presents the average annual growth of total labour supply in the period 2015 – 2050.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

Figure 1: Average annual growth of total labour supply in the period 2015 – 2050



3.2.2 Labour productivity and GDP

Increased labour supply makes a positive contribution to growth in the EU until 2020. However, the positive effect from a larger population as well as higher participation rate is more than offset by a decline in the share of the working-age population between 2020-2050. As a result, labour input contributes negatively to output growth in the long term, and labour productivity growth, driven by TFP growth, is projected to be the sole source of potential output growth over the projection period (European Commission, 2015).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

Annual average GDP growth in the EU is projected to remain quite stable over the long term. Up to 2020, potential annual growth is estimated to average 1.1%, after which it increases to an average of 1.4-1.5% until 2050, with significant differences across Member States. Labour productivity is expected to grow slightly below 1% until 2020 and increase to 1.6% in 2050 (European Commission, 2015). Table 4 summarises important variables.

Table 4: EU GDP and labour productivity

Macroeconomic variables	2020	2030	2040	2050
Potential GDP (growth rate)	1.4	1.3	1.3	1.5
Employment (growth rate)	0.3	-0.1	-0.2	-0.1
Labour input : hours worked (growth rate)	0.2	-0.1	-0.3	-0.2
Labour productivity per hour (growth rate)	1.1	1.4	1.6	1.6
TFP (growth rate)	0.7	0.9	1.0	1.0
Capital deepening (contribution to labour productivity growth)	0.4	0.5	0.6	0.6
Potential GDP per capita (growth rate)	1.2	1.2	1.3	1.5
Potential GDP per worker (growth rate)	1.1	1.4	1.6	1.6

Source: The 2018 Ageing Report: Statistical annex and tables

For EU-EMS, Figure 2 describes the spatial spread of average regional level GDP growth rates in the period 2015-2050. The highest growth rate is about 3% per year and the lowest growth rate is about -5% per year. These changes are driven by the combination of various factors underlying, with the most important being the development of regional population and hence regional labour supply. The economic growth is concentrated mostly in highly urbanized regions of Europe.

This project has received funding from the European Union's Horizon 2020 research and innovation programme
under grant agreement No 727114

Figure 2: Average annual growth of regional GDP in the period 2015-2050

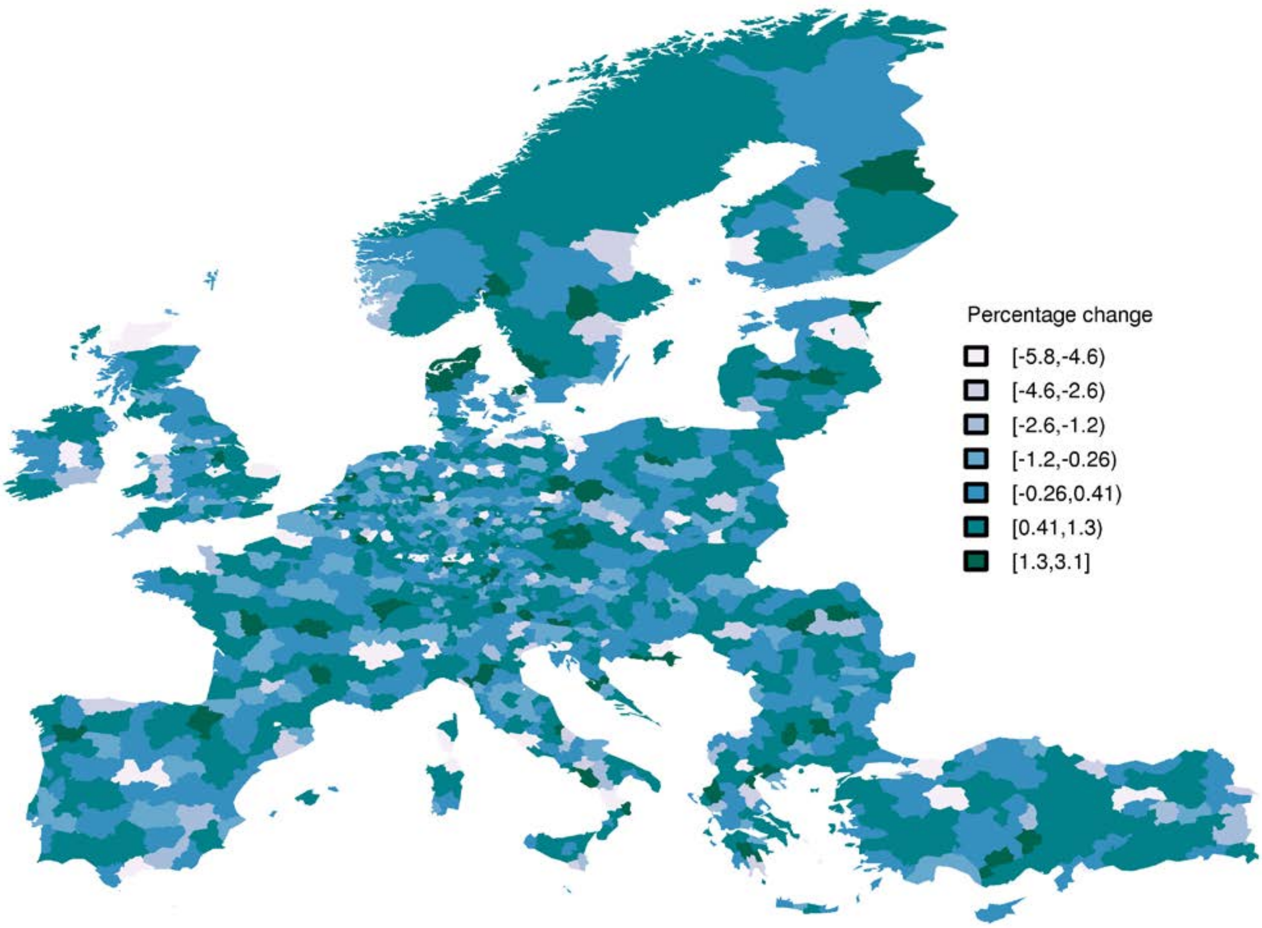


Figure 3 presents the levels of average annual decline rates for the twenty NUTS2 regions with the most negative growth rates combined with the information about average annual growth rate of their labour supply. As you can see for these regions, there is no clear correlation between the decrease in GDP and decrease in their labour supply. Economic slowdown in these regions are hence linked to negative changes in sectoral productivity and various indirect effects via supply-chain linkages of the SCGE model.

This project has received funding from the European Union's Horizon 2020 research and innovation programme
under grant agreement No 727114

Figure 3: Average annual growth of regional GDP in the period 2015 – 2050 for the twenty regions with the lowest economic growth

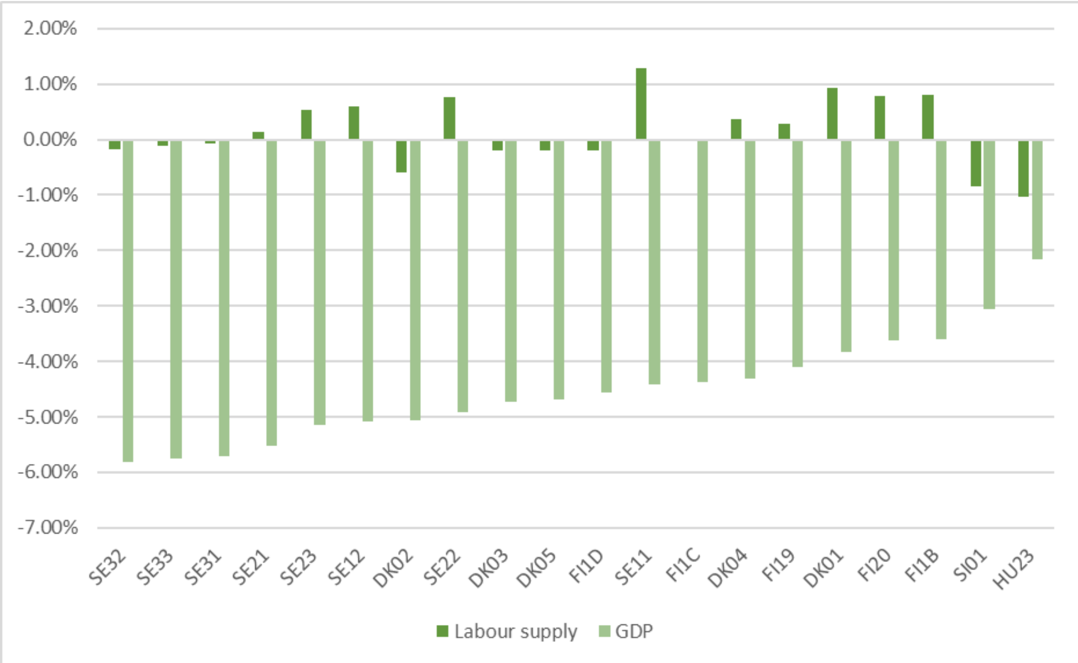


Figure 4 presents the NUTS2 regions that are associated with the highest average annual GDP growth in combination with the annual changes in their labour supply. For many of these fast-growing regions the motor of growth is rapid increase in their labour supply due to the combination of population growth and higher level of labour market participation rates. The positive change in labour supply is further enhanced by the positive productivity growth and various indirect effects.

This project has received funding from the European Union's Horizon 2020 research and innovation programme
under grant agreement No 727114

Figure 4: Average annual growth of regional GDP in the period 2015 – 2050 for the twenty regions with the highest economic growth

3.3 Energy and emissions

The EU Reference Scenario reflects current trends and developments in the EU energy system and in GHG emissions, where considerable changes are expected as a result of policies aimed at reducing GHG emissions, increasing the RES share, and improving energy efficiency (European Commission, 2016).

3.3.1 Greenhouse gas emissions

GHG emissions decrease in most sectors of the energy system, despite an increase in gross energy demand. This is particularly the case in the power generation sector, where several decarbonisation technologies reach maturity. The non-CO2 emission trends are diverse, with a substantial decrease in emissions from waste but only minor decreases in the agriculture sector (European Commission, 2016).

The ETS, which leads to continued reductions of allowances and increasing carbon prices over the projection period, is a significant driver of RES penetration. Energy efficiency

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

policies such as CO2 standards for cars and vans continue beyond 2020, with energy savings of 23.9% projected for 2030. CO2 emissions decrease significantly by 2050, presented for different sectors of the economy in Table 5 (European Commission, 2016).

Table 5: EU CO2 Emissions

CO2 Emissions	2020	2030	2040	2050
CO2 Emissions (Mt of CO2)	3,281.3	2,844.3	2,498.8	2,175.5
Power generation/District heating	1,058.7	865.4	671.0	393.4
Energy Branch	132.7	112.1	98.7	91.3
Industry	501.5	375.8	275.6	252.7
Residential	384.0	360.8	338.7	326.2
Tertiary	220.7	183.2	164.0	155.4
Transport	983.7	946.9	950.9	956.5
CO2 Emissions Index (1990=100)	78.9	68.4	60.1	52.3

Source: 2016 EU Reference Scenario (PRIMES)

3.3.2 Energy supply and consumption

The RES are projected to increase over the period due to implemented policies, and later in the period by the long-lasting effects of technological progress and better market functioning as the private sector engages increasingly. The economy is projected to grow until 2050, while total energy consumption is reduced over the same period – illustrating a continued trend of decoupling GDP growth and energy demand (European Commisison, 2016). Table 6 presents EU energy consumption, and Table 7 final energy demand by industry and fuel.

Table 6: EU energy consumption

Gross Inland Energy Consumption (ktoe) (%)	2020	2030	2040	2050
Solids	15.3	11.9	7.2	5.6
Oil	33.3	33.0	33.1	32.7
Natural gas	23.5	23.9	26.2	25.4
Nuclear	11.5	12.0	11.4	11.0
Renewable energy forms	16.3	19.1	22.1	25.4

Source: 2016 EU Reference Scenario (PRIMES)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

Table 7: EU Final energy demand (ktoe)

Energy Demand (ktoe)	2020	2030	2040	2050
Final Energy Demand	1,133,797	1,081,368	1,067,769	1,085,865
by sector				
Industry	295,323	269,765	249,035	251,839
- energy intensive industries	188,942	166,614	146,961	143,583
- other industrial sectors	106,381	103,150	102,073	108,256
Residential	298,155	288,051	287,594	291,562
Tertiary	186,487	179,075	180,629	184,234
Transport	353,833	344,477	350,511	358,230
by fuel				
Solids	45,711	34,285	18,469	13,392
Oil	405,293	373,318	358,889	352,635
Gas	264,623	241,000	234,095	236,649
Electricity	250,682	265,172	285,235	307,340
Heat (from CHP and District Heating)	50,935	54,346	56,136	56,700
Other	116,553	113,246	114,946	119,149

Source: 2016 EU Reference Scenario (PRIMES)

3.3.3 Electricity prices and system costs

In the PRIMES 2016 Reference Scenario, the changes in the power generation sector are dependent on substantial capital investments into the transmission and distribution systems, associated with higher energy system costs and electricity prices until 2030. The higher electricity prices do not, however, persist; they decrease in the long term, leading to a decreased ratio of energy system costs to GDP in the period 2030-2050 (European Commission, 2016).

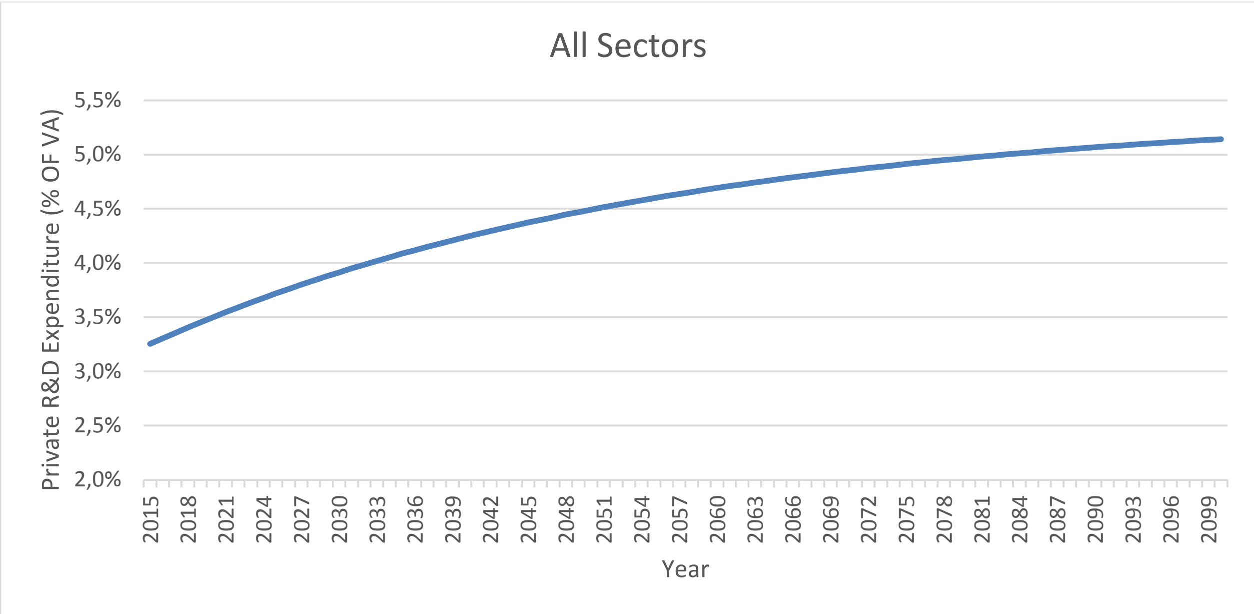
However, it should be noted that the projections for electricity prices and system costs are produced endogenously by the models and therefore no calibration is required for this indicator.

3.4 Research and innovation

On average, R&D expenditures are equal to roughly 3 per cent of total value added, with the highest shares being observed in industries comprising the high-tech manufacturing sector equal to roughly 10 per cent of total value added, while the lowest R&D investments as a fraction of value added is found within the traditional sector and equal to about 0.9 per cent. The levels of R&D investment do not significantly change from one period to another and likely to remain roughly the same in future periods.

On the aggregate, the projected series show a substantial increase in the expected level of R&D investments. Figure 5 shows that R&D intensity is expected to rise from 3.3 per cent – which was our sample average over the period in question, representing the current steady state - to slightly more than 5 per cent in the next few decades.

Figure 5: Projections for R&D intensity



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

4 Consistency with the baseline

This section describes how each of the models in the MONROE project calibrates and ensures consistency with the presented baseline indicators. It also explains why divergencies in Member State projections (based on the EU baseline data) may exist between the different models.

Table 8 gives an overview of the geographical coverage and main features of the models:

Table 8: Models and model characteristics

Model name	Geographical coverage	Main features
GEM-E3	World-wide, all EU28 countries separately	CGE model, recursive dynamic
PACE	World-wide, all EU28 countries separately	CGE model, recursive dynamic
E3ME	World-wide, all EU28 countries separately	Macro-econometric model
EU-EMS	NUTS2 regions of EU28	NGE model, recursive dynamic
DSGE	G7 + Eurozone ex-G7 + EU ex-Eurozone ex-G7 (i.e. 9 regions)	DSGE model with endogenous growth

4.1 E3ME

As an econometric model, it would be possible for E3ME to produce its own baseline projections. However, an extrapolation of the historical data would miss any forward-looking information (e.g. expected policy changes) that are not yet reflected in the data. The description in the calibration process in the E3ME model is described in the model manual (Cambridge Econometrics, 2014). We summarise it here.

To match the E3ME projections to a published forecast, the data first needs to be mapped to the model dimensions, including geographical coverage (59 regions), annual time periods, sectoral coverage, and national account entries. The results are saved on to a forecast databank.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

In the next step, E3ME solves the model and generates an exogenous, or 'calibrated', forecast. The model solves its equations, compares them to the results from the published forecast, and saves the differences in results onto a residual databank, while replacing the produced results with the published ones. This forecast ensures continuity between historical data and published projections (Cambridge Econometrics, 2014).

Lastly, an endogenous forecast is produced. The model solves its equations again, but the residuals are added on to the results (similar to adjusting the intercept term in the econometric equations). Theoretically, the final results should be the same as for the exogenous forecast, but in practice errors occur so that they do not match perfectly. The key difference is that inputs in the endogenous baseline can change in order to produce the desired outcome. This final outcome is the endogenous baseline forecast, matched to published projections, which can be used for comparison with scenarios.

To illustrate with an example, consider the PRIMES scenario. The PRIMES scenario provides results for economic activity as a driver of energy demand, but only presents aggregated results on a few indicators (GDP, household spending, value added in energy intensive sectors etc.) for a smaller number of countries. As the complete structure of the national accounts is represented in E3ME, other economic variables must be estimated in a way that is consistent with the PRIMES figures. The estimation is done in a way so that e.g. the components of GDP sum up to the correct total, and that similar indicators, such as gross and net output, follow the same growth patterns. After this exercise, E3ME solves the exogenous forecast, saves the residuals to a databank while calibrating to the published results. Lastly, the endogenous forecast is projected. The result of this exercise is a set of baseline projections that is both consistent with the published figures and the integrated economy-energy-environment structure of E3ME (Cambridge Econometrics, 2014).

4.2 GEM-E3

The development of a consistent baseline projection for an economy is a quite complex task as GDP growth can follow different patterns (i.e. it can be export or investment driven) and attributed to different growth mechanisms (i.e. technical progress, population growth,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

capital accumulation) and certain climate and energy policies can be captured though the mechanism in the model by using different supply side and/or demand side channels.

In this respect the construction of the GEM-E3 model baseline scenario is based on specific verifiable macroeconomic and technological assumptions which reflect a predefined projection regarding the economic, energy and environmental structure of the regions represented by the model.

At the beginning of the calibration process a feasible set of values is defined in certain dynamically calibrating exogenous variables of the model; each one corresponds to predefined economic, energy or environmental targets. GEM-E3 solves the model and provides a solution that reflects the predefined projection structure of the regions via a set of target equations that are included in the model for the baseline process. In parallel expected values for each one of the dynamically calibrating exogenous variables are set based on estimated trends from historical data or on available literature.

The final outcome of the baseline procedure is a set of values for the dynamically calibrating exogenous variables that reflects the predefined economic, energy or environmental targets and achieves the minimum value of the overall weighted distance measure[2].

4.3 PACE

The baseline calibration of the PACE model is described in detail in EASME (EASME, 2017). Calibration of CGE models requires a balanced social accounting matrix (SAM) so that transactions between sectors and the representative agent and government can inform the production functions of sectors and utility function of agents. Production and utility functions are calibrated such that cost-minimizing firms and utility maximizing agents make exactly the choices that lead to the transactions represented by the SAM. In the context of climate change policy, due to the necessity of measuring emissions in terms of physical units rather than value flows, the SAM has to be complemented by quantitative

[2] A weighted sum of the distance of each target from its expected value.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

information about the energy and fuel consumption of the sectors and agents which corresponds to the SAM's value flows. In addition to this calibration to a benchmark year of the world economy, assumptions about future growth patterns of regional GDP on the one hand and sectoral energy use on the other are crucial to a multi-period analysis of climate policy. Growth of GDP can be induced by letting the availability of the production factors increase by the corresponding rates for each region. The model, assuming production and utility functions as in the base year, will then endogenously balance trade imbalances caused by asymmetric growth of regions. To reproduce assumptions about changes in energy intensity of economic activities, however, the production functions themselves have to be changed. Again, changes to the production function are introduced (e.g. the share of energy needed to produce a given amount of output is decreased and other inputs increased) and the model is endogenously rebalanced. In the following the data this calibration process is based on for the PACE model is described in more detail.

The PACE baseline relies on three principal sources, GTAP 9 (Global Trade Analysis Project), the EU Reference 2016 Scenario (as previously described in this report), and the International Energy Outlook by the US Department of Energy. The first time period modelled by the PACE model is 2010, and the model then proceeds in steps of five years. The starting period 2010 is calibrated using interpolated data for 2011 from the GTAP 9 data base. GTAP 9 provides detailed information, e.g. on sectoral and regional production, trade relations and energy use, for the base years 2004, 2007 and 2011. In the MONROE project data for the base year 2011 is used for model calibration. Elasticities of substitution in international trade (so-called Armington elasticities) are based on empirical estimates reported in the GTAP database. Certain CES elasticities of substitution between production factors (capital, labour, energy inputs, and non-energy inputs) are taken from Okagawa and Ban (2008) based on recent sectoral panel data estimates for the period 1995 to 2004 (Okagawa & Ban, 2008).

Data for the future economic development are taken from the International Energy Outlook of the US Department of Energy for the non-EU regions (IEO, 2016). The 2013 IEO provides detailed regional data on total and fuel-specific primary energy consumption and carbon emissions given assumptions on the development of GDP, fossil fuel prices and other

This project has received funding from the European Union's Horizon 2020 research and innovation programme
under grant agreement No 727114

factors. For the EU regions, a specific baseline based on projections from the EU Reference Scenario 2016 is used for calibration. Furthermore, projections on indicators such as GDP, fuel and CO2 prices, and electricity generation are incorporated into the PACE baseline.

4.4 EU-EMS

The detailed information about the EU-EMS model and its baseline module is presented in deliverable with the description of all the relevant modelling features (upcoming deliverable D4.11). Due to the geographical scope of NUTS2 regions, EU-EMS has a more detailed baseline as compared to the other models, but on aggregate EU Member State level the baseline is consistent with population projections of Eurostat. The EU-EMS baseline module is based on the resent theories of structural economic change and combines econometrically estimated sector-specific TFP (Total Factor Productivity) changes, changes over time in the preferences of households as a result of changes in their income levels with supply and supply-chain linkages of the spatial CGE model. The EU-EMS model parameters are not calibrated on any specific baseline which is justified by the absence of official regional growth scenarios for Europe. Baseline scenario of regional economic growth is generated endogenously by the model via the combination of empirically based sector-specific productivity and households' preference changes in combination with population projections of Eurostat and IIASA scenarios of education levels.

4.5 DSGE model with endogenous growth

The DSGE model is mentioned in this section as it is one of the models used in the MONROE project, but it does not have a baseline with the same meaning as the other models. The full model is described in other deliverables, but a few things are worth noting also in this section.

The DSGE model with endogenous growth is designed to match the behaviour of key macroeconomic variables across countries over a long period of time. The model is estimated on aggregate time series date from several countries with data starting in 1870. The chief

This project has received funding from the European Union's Horizon 2020 research and innovation programme
under grant agreement No 727114

dataset is the Jordà-Schularick-Taylor Macrohistory Database which covers 17 countries, but this is augmented with data from the US NIPA, Eurostat, and the Penn World Tables.

The DSGE model generates predictions for all the time series it uses in estimation. The predictions may differ substantially from the "baseline" scenario considered by others in the consortium. However, given that the DSGE model is linearized, this will have no impact on policy conclusions. Linearity means that in the DSGE model, if some tax is temporarily increased by 1% then the percentage change in output growth, R&D etc. will be independent of the path the economy would have followed were it not for this temporary tax change. Of course, the absolute level of output growth, R&D etc will depend on the path in the absence of the tax change, but the change in these variables will not. This linearity result does not hold for permanent changes in policy instruments (as these change the non-stochastic steady-state about which the model is linearized), but given such changes imply an implausible ability of current governments to affect the actions of future ones, the DSGE model only look at the effects of temporary changes.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727114

5 Conclusion

As the policy scenario results are usually presented as differences from the baseline, as opposed to absolute forecasts, it may appear as though the actual levels in the baseline are less important – this is not the case and larger differences may make results more difficult to compare. However, due to the differences in model solutions and economic assumptions, there will be small differences in baseline projections despite having similar baseline sources to calibrate to. These small differences imply that the differences in model results may be attributed in different modelling principles and not to different baseline scenarios.

Thus, consistent baselines with only small differences across models do not ensure that the dynamics of the models are the same. The key difference lies in the way that these projections are simulated in each model. In particular, differences occur in: (i) implied productivities, (ii) structure of GDP (i.e. GDP growth through an investment-driven or a consumption driven approach), (iii) structure of value added (i.e. GDP growth based on industry or services expansion) and (iv) composition of skills. These differences must be considered when analysing scenario results, but the similarity of baseline sources actually makes the exercise more compelling.

The baseline is a projection – not a forecast. It provides a model-derived simulation of one possible future state given certain set assumptions and conditions. Following this, the baseline can help inform policy makers on where currently adopted policies might lead and provides a point of comparison toward which new policies can be measured on impact and effectiveness. Transparency in baseline assumptions are critical for evaluation, policy recommendations and conclusions. An annex with baseline data from the different models is available upon request as part of the MONROE project.

References

Cambridge Econometrics. (2014). *E3ME Technical Manual, Version 6.0.* Cambridge: Cambridge Econometrics.

EASME. (2017). *EU Competitiveness and the 2030 Framework – An Industry Perspective, Final Report. Executive Agency for Small and Medium-sized Enterprises.* Brussels. doi: 10.2826/830079: Directorate-General for Internal market, Industry, Entrepreneurship and SMEs (GROW), European Commission.

European Commisison. (2016). *EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050.* Brussels: European Commission with E3M-Lab, IIASA, Euro-CARE.

European Commission. (2015). *The 2015 Ageing Report: Economic and budgetary projections for the 28 EU Member States (2013-2060).* Luxembourg: Directorate-General for Economic and Financial Affairs.

IEO. (2016). *International Energy Outlook.* Washington DC. http://www.eia.doe.gov/oiaf/ieo/: EIA, US Energy Information Administration.

Okagawa, A., & Ban, K. (2008). Estimation of Substitution Elasticities for CGE Models. *Osaka University*, http://www2.econ.osaka-u.ac.jp/library/global/dp/0816.pdf.

UN. (2017). *World Population Prospects: The 2017 Revision - Key Findings and Advance Tables.* New York: United Nations.