A TIME TO SOW, A TIME TO REAP* FOR THE EUROPEAN COUNTRIES: A MACRO-ECONOMETRIC GLANCE AT THE RTD NATIONAL ACTION PLANS

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In this contribution, we present an assessment, in terms of growth, employment and competitiveness, of the European Union Member States RTD policies in late 2004, the National Action Plans (NAP). The assessment in this paper is based on the results of a detailed macro-econometric model NEMESIS for the European Union countries. The results refer to two different periods: first, the "Time to Sow", during which increased RTD effort is rewarded by few innovations. This is a period of delayed RTD maturation. The economy is demand oriented, and GDP and employment levels are multiplier based, while inflationary pressures and deficits abound. Second, the "Time to Reap", when a virtuous mechanism of innovation based growth and employment is engaged, which should lead European countries to a less material, less polluting knowledge economy.

JEL Classification: C53, D78, E17, O33, O38, O47.

Keywords: Policy Assessment, RTD, Growth, Econometric Modelling, Endogenous Technical Change, Sustainable Growth

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* Although originally created for another context, we can not help adopting the beautiful formula of HELPMAN and TRAJTENBERG [1998], which is well suited to our work.

We are very grateful to P. Valette, D. Rosetti, G. Klaassen from European Commission, who did support the building of the NEMESIS model and who took an active part in monitoring this research finded by DG Research, and U. Muldur and H. Delanghe European Commission who assessed the 7th Program. We are also indebted to many people involved in this study, especially D. Brécard (Erasme and LEN) and L. Lemiale (Erasme and LEN).

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Heads of States and governments who met at the European Council of Lisbon in March 2000 made the decision to lead Europe towards becoming "the most competitive and dynamic knowledge based economy in the world…" The Barcelona policy of March 2002 echoed this objective and fixed the target of 3% R&D intensity by 2010, in order to close the gap with the United States and Japan, where R&D intensity is at roughly this level.

This paper differs from other studies that focused on an assessment of the Barcelona policy (see Brécard *et alii,* 2004, 2006). In this paper we concentrate on less ambitious national plans than Barcelona objective and examine recent orientations in the European budgets for research, on the assumption that Europe will engage from 2007 (beginning of 7th FP – research Framework Program) in a reinforcement of its research budget. In our study we hypothesise that, once the 3% target has been achieved, there will be a stabilization in effort, rather than continued increase to 3.5% by 2030.

A particular feature of R&D policies is that their main effects take place over long time periods; These time periods represent the time taken for R&D investments to produce innovations and for these innovations to penetrate the market. The time period involved could be infinite if the efforts are not fruitful, but generally is of the order of several years (three years for private research, up to five years for public basic research). Implementing such policies in an applied model leads to identify two distinct periods, to involve their quantification and to give credible figures to different macro economic mechanisms sustaining them. These two distinct phases are:

The "Sowing period" during which GDP growth is mostly induced by increases in expenditures and employment linked to research. During this period, very little supply effects will appear; deficits, the private one (as the Lisbon strategy is mainly based on the private financing to research contribution) and external deficit will increase.

The "Reaping period", during which R&D investment begins to produce innovations that substantially modify the supply and demand conditions: process innovations enable a decrease in the prices of goods and services; product innovations increase the quality of goods and services. This enables a period of growth based on strong internal demand, competitiveness and the restructuring of economic activities towards knowledge based productive sectors.

The model applied in this study is the European detailed sectoral econometric model, NEMESIS, which was developed to evaluate R&D policies by endogenizing technical change (process and product innovations).

The paper is organised in three parts. The first is devoted to "A Time to Sow", presents NEMESIS' mechanisms involved in that period and highlights the different characteristics of the sowing, especially related to employment and GDP, on financing problems and on competitiveness. In the second part, “from Sowing to Reaping” we describe the innovation mechanisms involved in NEMESIS. The third part, “the Time to Reap”, describes the characteristics leading to an economic restructuring of the knowledge based economy envisaged by the Lisbon agenda.

1. A Time to Sow

In the period 2004 to 2010, national policies are implemented and R&D expenditures increased. The sharp rise in R&D investment is not accompanied by supply side effects until innovations mature. GDP growth is then mainly explained by a Keynesian multiplier, which produces a deepening of the deficits. We present NEMESIS's mechanisms that are involved in this sowing period, the R&D policiy implementation in the model, and impacts on the main macroeconomic indicators for Europe.

1.1. The sowing period effects in NEMESIS

The Sowing period effects are mainly short term resulting from increased RTD. The NEMESIS model is traditional in the sense that its short term mechanisms are grounded in the neo Keynesian view of macroeconomics: prices result from monopolistic competition behaviour whereby producers add a mark-up to production prices; at these prices, demand is too low to clean up the market, and so in the short term there is a phase of effective demand:

The direct effects of R&D expenditure are twofold. First, as R&D is labour intensive, labour demand rises. Second, as part of them consist in investments and intermediate consumption, demand rises producing increases in production and employment.

Prices increase for two reasons: unemployment is reduced leading to wage rises through a Phillips effect, and R&D augments direct production costs and thus prices.

The rise in real wages boosts final consumption, and there is a multiplier effect.

This price effect reduces competitiveness and worsens trade balances, lowering exports and increasing imports. The multiplier level will be proportionate to these effects.

After 5 years, supply side effects begin to make results; for reasons of simplicity and pedagogy, we predict that the the main effects will be on demand until 2010. Thus, we term the 2004-2010 period the “sowing period”. This hypothesis is confirmed by a low increase in factor productivity in 2010 of only 0.51% above the business as usual scenario level, supply side effects being very weak.

1. Member States Action Plan for RTD (2010)

	Situation in 2003	Objective for 2010
Austria	1.94	3.00
Belgium	2.17	3.00
Denmark	2.40	3.00
Germany	2.49	3.00
Finland	3.40	3.50
France	2.23	3.00
Greece	0.67	1.50
Ireland	1.17	2.80
Italy	1.07	1.75
Netherlands	1.94	3.00
Portugal	0.84	1.00
Spain	0.96	1.50
Sweden	4.27	4.27
UK	1.84	3.00
Europe	1.99	2.75

Source: ECFIN 2004

1.2. The sowing period implemented in the model: R&D increases

This 3% R&D investment objective for Europe is actually very ambitious when one considers that RTD expenditure in 2005 was only about 2% of GDP. If the objective is to be reached RTD expenditures will have to increase by 0.2 points GDP per year, from now until 2010 across Europe i.e. a rise of more than 20 billions per year.

Table 1 below summarises the 2004 RTD action plans of the EU-15 for 2010[1]. The table shows that if Members States stick to these action plans, the RTD intensity among the EU-15 will reach 2.75% of GDP in 2010, representing a rise in European RTD GDP intensity of about 0.76%.

Of the 14[2] countries included in the table, nine are at or are forecast to reach the 3% level by 2010 (Finland and Sweden); countries in southern Europe, which have the lowest initial levels of RTD intensity, have established a more modest objective of about 1.50% of GDP by 2010.

1. Some member states have modified their action plans for RTD (see ECFIN/EPC(2005)REP/55392 final: "Report on the Lisbon National Reform Programs 2005"). Some of the differences include: Finland (4% against 3.5%), Ireland (2.5% in 2013 against 2.8% in 2010), Italy (3% against 1.75%), Spain (2% against 1.5%), and United Kingdom (2.5% in 2014 against 3% in 2010). The most significant change relates to Italy, which increased its RTD intensity objective for 2010 by 1.25 GDP points.

2. Luxembourg was regrouped with Belgium for this study.

2. European RTD Funding between 2007 and 2015 (FP)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Funding to RTD in GDP Points	0,048	0,062	0,076	0,090	0,104	0,117	0,131	0,145	0,159	0,173

To get a more complete picture of the future of European research, we need to take into account the contribution of European funding to European RTD intensity. This funding has had more major macroeconomic impacts than national funding, based on the crowding-in effects they produced on national research efforts.

Empirical studies on public subsidies for R&D, indicate that, on average, a subsidy of 1 euro produces more than 1.7 euros of additional R&D expenditure (see for example Guellec and van Pottelsberghe de la Potterie [2003]). European funding also leads to greater knowledge externalities and more research results than national funding, because European research networks gather the best researchers in each country, which enables the sharing of knowledge and experience and exploitation of complementarities.

It is envisaged that from 2007 (beginning of 7th FP) Europe will engage in a reinforcement of its research budget in order to accompany Member States into their increased RTD investments. We assume that the reinforcement of European research budget is not taken into account in Member States National Action Plans, and that it will increase the RTD effort.

According to the scenario proposed in this study, the European research budget will increase from some 0.05 points of GDP in 2006 to 0.173 points of GDP in 2015 (see Table 2), that is to say an increase of about 0.014 GDP points per year over nine years.

We have assumed that European funding will have an average crowding-in effect of one on national funding, i.e. each 1 euro subsidy producing an additional 2 euros of R&D expenditure[3].

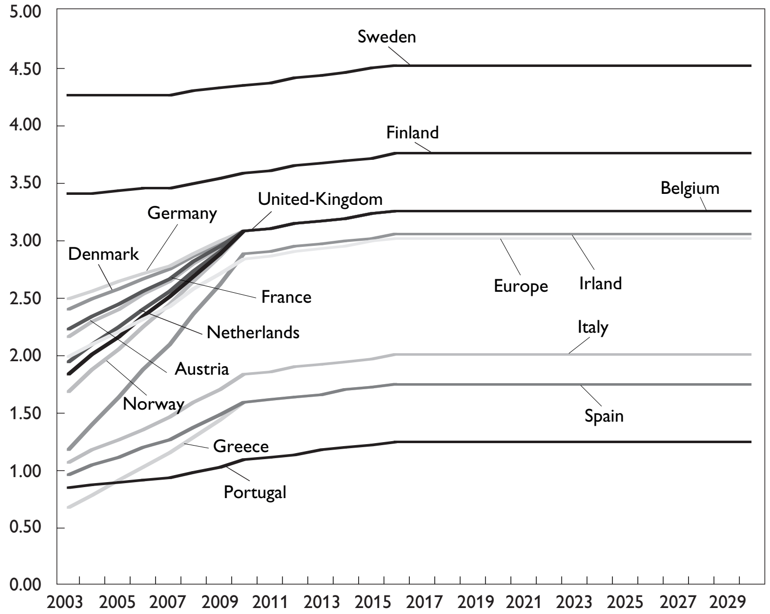
We have also assumed that this European funding will be allocated proportionally to each member state, allowing them to increase their annual RTD intensity by 0.028 points GDP[4].

Under these assumptions, increased European funding will allow RTD intensity to increase by 0.25 point by 2015, and, assuming that member states maintain their RTD efforts after 2010, this will enable the EU-15 to

3. The crowding-in effect assumes zero subsidies for the public sector, and 1.3 for the private sector.

4. The share of subsidies between the public and the private sectors is assessed on the basis of practice established in the 5th framework programme.

Graphique 1. RTD intensity in the NAP + FP scenario: 3% in 2015 for EU-15*



* Norway was added on the graph, the version of NEMESIS model used for this study including EU-15 countries plus Norway.

reach the Barcelona 3% RTD objective in 2015, with a constant RTD intensity after this date (see Graph 1).

The RTD intensity forecast for the Member States and Europe is summarised in Table 3.

One can see that by assumption European countries will progressively adjust to their 2010 NAP objective, and that the rise in European funding adds to these action plans, allowing the 3% RTD objective to be achieved between 2014- 2015.

In the simulation the horizon was extended to 2030, although with RTD intensity stablising from 2015. In order to assess the long term impact on European economies of the Barcelona scenario, its full impacts occurring during the reaping period described afterwards, when innovations resulting from past research widely diffuse on the market.

The other assumptions in this scenario are in line with the Barcelona objective: additional R&D efforts will be concentrated in the private sector, producing private financing of RTD at 2 points of GDP in 2015 as opposed to 2010 based on the Barcelona agenda.

3. RTD Intensity in NAP + FP Scenario

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Austria	1,94	2,09	2,24	2,39	2,57	2,75	2,93	3,11	3,14	3,17	3,20	3,22	3,25
Belgium	2,17	2,29	2,41	2,53	2,67	2,82	2,97	3,11	3,14	3,17	3,20	3,22	3,25
Denmark	2,40	2,49	2,57	2,66	2,77	2,88	3,00	3,11	3,14	3,17	3,20	3,22	3,25
Germany	2,49	2,56	2,64	2,71	2,81	2,91	3,01	3,11	3,14	3,17	3,20	3,22	3,25
Finland	3,40	3,41	3,43	3,44	3,49	3,53	3,57	3,61	3,64	3,67	3,70	3,72	3,75
France	2,23	2,34	2,45	2,56	2,70	2,84	2,97	3,11	3,14	3,17	3,20	3,22	3,25
Greece	0,67	0,79	0,91	1,03	1,17	1,32	1,47	1,61	1,64	1,67	1,70	1,72	1,75
Ireland	1,17	1,40	1,64	1,87	2,13	2,39	2,65	2,91	2,94	2,97	3,00	3,02	3,05
Italy	1,07	1,17	1,26	1,36	1,49	1,61	1,74	1,86	1,89	1,92	1,95	1,97	2,00
Nether.	1,94	2,09	2,24	2,39	2,57	2,75	2,93	3,11	3,14	3,17	3,20	3,22	3,25
Portugal	0,84	0,86	0,89	0,91	0,96	1,01	1,06	1,11	1,14	1,17	1,20	1,22	1,25
Spain	0,96	1,04	1,11	1,19	1,30	1,40	1,51	1,61	1,64	1,67	1,70	1,72	1,75
Sweden	4,27	4,27	4,27	4,27	4,30	4,33	4,35	4,38	4,41	4,44	4,47	4,49	4,52
UK	1,84	2,01	2,34	2,34	2,53	2,72	2,92	3,11	3,14	3,17	3,20	3,22	3,25
Europe	1,99	2,10	2,32	2,32	2,46	2,60	2,73	2,87	2,90	2,93	2,96	2,99	3,02

1.3. The sowing period: multiplier based GDP, inflationary pressures, deepening of deficits

Throughout the first phase to 2010, the European economy will be "boosted" by the spontaneous increase in R&D expenditure. In 2010, GDP growth will be 1.36% for an increased R&D expenditure of 0.87% of GDP, equivalent to a multiplier (which has not yet reached maturity) of 1.56.

During this sowing period, R&D maturation times of 3 years for private R&D and 5 years for public R&D according to the NEMESIS model, will be such that productivity increases only slowly: total factor productivity increases by only 0.51% in 2010. These low productivity gains explain the "multiplier" nature of the policy for increasing R&D expenditure.

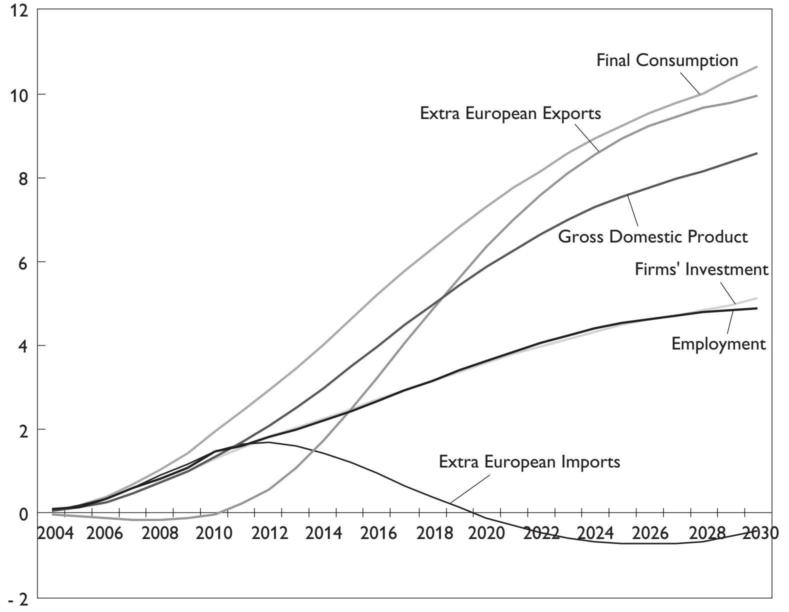
GDP growth and increases in employment and real incomes, are driven by the Phillips curve. Employment increases by 1.47% in 2010 and real disposable income by 2.40%. Up to 2015, employment growth is greater than GDP growth (Graph 2 below), which, from a macro-economic point of view, may seem curious (employment normally increases long after GDP), but may be explained here by the high employment content in R&D expenditure.

4. Macroeconomic Results for Europe*

	2004	2010
Demand.		
– Final Consumption	0.07	1.94
– Public Consumption	0.06	0.51
– Total Investment	0.08	1.66
- Firms' Investment	0.05	1.33
– Intra European Trade	0.03	1.12
– Extra European Imports	0.06	1.47
– Extra European Exports	-0.02	-0.02
– Gross Domestic Product	0.06	1.36
Employment	0.08	1.47
Research and Productivity.		
– Research and Development	6.27	58.19
- private sector	7.34	68.34
– Research Intensity**	2.10	2.84
*- private sector***	1.20	1.86
– Total Factor Productivity	0.04	0.51

* in % Deviation w.r.t. the Baseline except Research Intensity
** Absolute value in scenario

Graphique 2. Macro-economic impacts in Europe*



* As a % compared to the trend-based count

All internal demand headings increase. In particular, increasing consumption, up by 1.94% in 2010, plays a predominant role due to the increase in employment and real income. Total investment is up by 1.66% in 2010.

Price changes in this exercise differ from those of a standard Keynesian reflationary policy. In fact, most financing of the extra R&D in 2010 is provided by companies, who pass the extra cost in prices[5] in line with monopolistic competition behaviour based on a constant mark-up on costs. Consequently, the inflationary character of the R&D policy is more pronounced than in a simple public expenditure policy (Gaffard, 2003). Prices thus increase under the concomitant influences of boost to demand and financing R&D expenditures.

5. The assumptions in the reference scenario is that in 2015 two-thirds of R&D will be financed by private firms. Between 2003 and 2010 R&D expenditures increase by 1% of GDP (from 1.99% to 3%) including a rise in business R&D intensity of 0.86% and a rise in public expenditures for research of 0.14 of GDP, from which 0.125 is financed by European budgets. We retained the assumption that the increase in the European budget for research will not increase the overall European budget and substitute for other expenditures. The *ex-ante* deficit for the European member states is therefore limited to 0.015% of the *ex-ante* GDP in 2015 and it is private companies that finance most of the R&D supplement.

The boost to demand, combined with price rises, weighs on Europe's external trade: imports increase by 1.47% and exports fall by 0.02% in 2010. The external deficit therefore rises during this period, which explains the "relative" weakness of the multiplier, in spite of the low extraversion rate of Europe (only 10 % of European trade is carried out with the rest of the world).

The macro-economic mechanisms operating for each individual country in this sowing period are the same as for Europe as a whole, but they vary according to the size of the RTD effort. The impact of the increase in R&D may vary according to each country's characteristics, but it is the size of the extra RTD effort that will determine the size of the impacts on macro-economic indicators.

Globally speaking, the impact of expenditure is greater for those states with the most ambitious NAPs in terms of additional RTD effort in 2010. Therefore, at the start of the period, these countries will see a greater rise in GDP— until 4.04% for Greece, which shows the highest increase in RTD intensity, against 0.48% in Sweden, which shows the smallest increase in RTD effort— but will loose more in terms of relative competitiveness at the end of this sowing period.

2. From Sowing to Reaping: The mechanism of Innovation in NEMESIS

The "germination", which follows the sowing and leads to reaping, can be synthesised by modelling the RTD based endogenous technical change process in NEMESIS.

In fact, to adapt the model to the new theories of growth and technical change, we need to include several phenomena: the endogenization of technical change (innovation), spillovers (knowledge transfers) effects, and the economic consequences of innovation. We know that renewal in growth theory is grounded in the non-decreasing returns hypothesis which allows for accumulation without saturation of production factors such as investment, R&D or knowledge, and human capital (Romer, 1986, 1990; Aghion and Howitt, 1992). The property of non decreasing returns allows the long term growth rate to be endogenised and justifies the rehabilitation of R&D and growth policies.

In new growth theory, the knowledge variable and its externalities play a major role in the endogenisation of technical change and in explaining non decreasing returns[6].

6. We do not speak about controversies on the scale effect (JONES [1995])

We examine how this knowledge variable is built and how innovations and economic performance are endogeneized on it, then, we will describe calibration of these pheneomena.

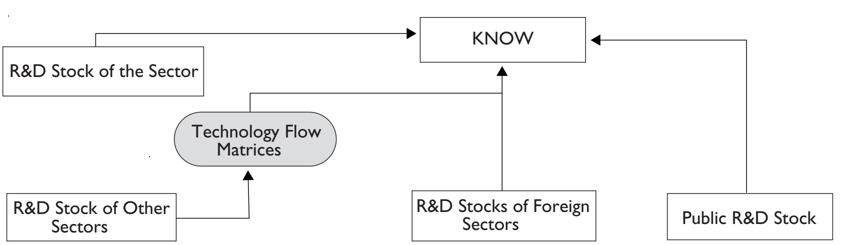
2.1. The knowledge variable

The variable that plays a major role in the endogenisation of technical progress in NEMESIS is the variable KNOW, for knowledge, that arises out of the R&D stock and which plays a vital role in technical progress. A sector's R&D stock is determined by its R&D expenditure and a constant scrapping rate. It is constituted as a stock of capital, with scrapping being the gradual deletion of knowledge (figure 1).

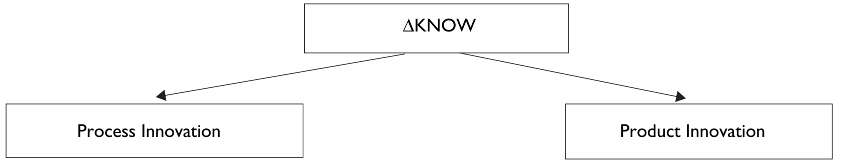
1. From R&D expenditure to the R&D stock

Knowledge is determined both by the sector's R&D stock and also by the knowledge spillovers in all national and foreign sectors (figure 2). Knowledge spillovers from other sectors are dependent on their stocks of R&D, and are illustrated by technological flow matrices. These matrices, which are differentiated by sector and by country, are constructed according to the methodology developed by Johnson for the OECD (Johnson, 2002). This involves identifying, for every patent registered at the European Patent Office (EPO), the sectors producing and using the innovation described in the patent. This is then used to determine how much the knowledge accumulated in one sector will benefit other sectors, by calculating the knowledge transfer coefficients, the knowledge, by assumption, being borne by the patents. This involved over 100 sectors, with the results being re-agglomerated in the NEMESIS sector-based nomenclature in the form of technological flow matrices. Knowledge also feeds on R&D stock in foreign sectors and on public sector R&D stock.

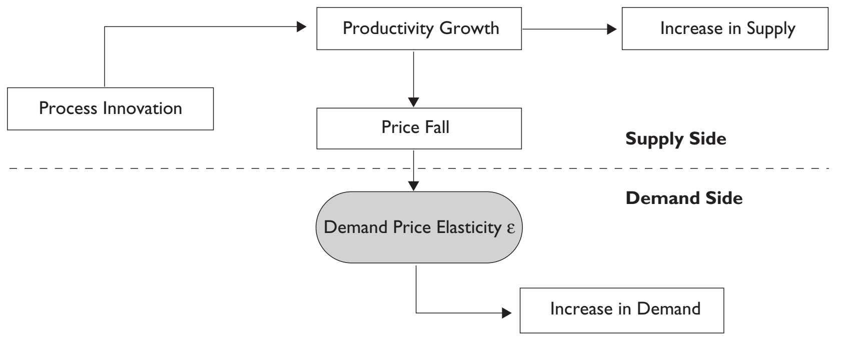
2. The stock of knowledge



3. Two types of innovation



4. Process innovation and economic performance



2.2. From stock of knowledge to innovation and economic performance

Innovations are determined by the variant in the stock of knowledge (figure 3). Two types of innovation are considered in NEMESIS:

process innovations, which increase the global productivity of factors in the specification that we have chosen;

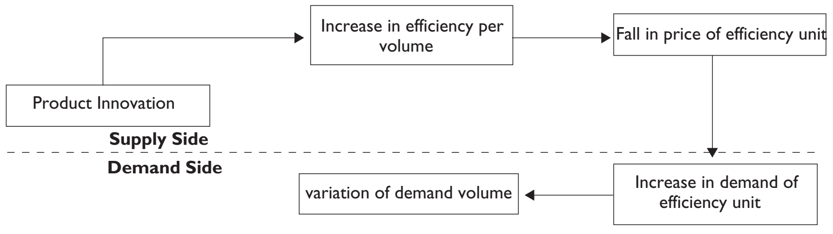
product innovations, which, in the fixed nomenclature of national accounting that underpins NEMESIS, are shown in quality improvements.

These two types of innovation affect economic performance differently.

Process innovation does not produce the same effects as product innovation. Process innovation increases total factors productivity, thus increasing product supply and reducing unit production cost, and therefore prices. Price reductions lead to increased demand, which is dependent on price elasticity (figure 4).

Growth in demand helps to absorb the extra supply (at a constant usage level) if demand price elasticity is higher than or equal to 1. However, econometric estimates in chronological series reveal an elasticity generally lower than 1 for each sector, and thus for the whole economy. This is based on a representative firm per sector: We do not consider the innovative firm to be in competition with other companies in

5. Product innovation and economic performance



its activity sector. This then assumes that all firms in the sector innovate and reduce their prices. Increased demand then depends on the capacity for absorption represented by elasticity lower than 1. In this case process innovation reduces the use of factors as supply effects outweigh the effects of demand.

Product innovation acts like an increase in efficiency per volume unit and increases demand for units of efficiency (figure 5). Volume production is only maintained if the increase in demand for the new efficiency is equal to the increased efficiency due to innovation. Generally, product innovation more than compensates for the fall in factor usage due to process innovation. R&D therefore simultaneously leads to an increase in GDP and in the use of factors.

The *ex ante* effects of innovation on GDP depend on the effects of the increase in knowledge on the global productivity of factors and on quality and thus on demand: increased production is in fact linked to increased demand arising respectively from process innovation and quality innovation (box 1).

Finally, economic performance, measured by increased production due to increased knowledge, can be written as: $\frac{\Delta Y}{Y} = \beta \frac{\Delta KNOW}{KNOW}$

2.3. The calibration of mechanisms

Most econometric studies link increased production to an increase in R&D stock: $\frac{\Delta Y}{Y} = \alpha \frac{\Delta SRD}{SRD}$.

Various surveys (see for example Mohnen, 1990; Griliches, 1980; Mairesse and Sassenou, 1991; Cameron, 1998) reveal a rather broad range for parameter a of 0.05 to 0.2. The results are independent of the methods chosen. However, where α is estimated using instant cross-section series (inter-companies), it is higher than when estimated chronologically (cf. section 1.1).

Box 1. The effects of innovation on economic performance

– Process innovation: the accumulation of knowledge (KNOW) generates an increase in total factor productivity (TFP).

$$\frac{\Delta TFP}{TFP} = a\frac{\Delta KNOW}{KNOW}$$

– Product innovation: the accumulation of knowledge (KNOW) leads to an improvement in quality (QUAL).

$$\frac{\Delta QUAL}{QUAL} = a\frac{\Delta KNOW}{KNOW}$$

– Economic performance: increased production (Y) depends on increased demand due to innovation.

$$\underbrace{\frac{\Delta Y}{Y}}_{\text{Production Increase}} = \varepsilon\underbrace{\frac{\Delta TFP}{TFP}}_{\text{Demand Increase from process Innovations}} + \underbrace{\varepsilon'\frac{\Delta QUAL}{QUAL}}_{\text{Demande Increase from product Innovations}}$$

$$\text{i.e. } \frac{\Delta Y}{Y} = (\varepsilon a + \varepsilon' a')\frac{\Delta KNOW}{KNOW} = \beta\frac{\Delta KNOW}{KNOW}$$

This large spectrum of values for α in the empirical studies prompted us in our previous assessment of the Lisbon strategy's 3% RTD objective in 2004, to construct scenarios based on different values for our β parameter. The β value was differentiated by country and production sector, depending on the level of RTD intensity achieved, in order to allow a convergence of rates of return of knowledge across countries and sectors. We again used an initial value of 0.075 for β in 2004, and the same low of evolution after 2004. On this basis the β value reaches 0.107 in 2030, which is about average in terms of the results of econometric studies for α.

3. A Time to Reap

During the second period from 2010, the increased RTD efforts will begin to show their full effects. The amount of RTD invested since 2004, which has now matured, is very important. There is no significant increase in RTD intensity after 2010; only 0.14 GDP points, the result of the increasing size of European RTD Framework Programmes up to 2015. This is the beginning of the reaping period, which is characterized by introduction of innovations, with all their consequences on growth, employment and sectoral restructuring of European economies. The growth dynamic is characterised by a continuous process of innovation, which increases productivity and the quality of goods, is embarked upon. There is neither discontinuity nor huge radical innovation. This process is referred to as "incremental innovation", a stage that is necessary for all the econometric based work on innovation.

The reaping period illustrates the potential gains to be obtained as a result of European countries closing the gap with the US and Japan through investment in knowledge. We begin by describing the macroeconomic characteristics of this new stylized growth and the restructuring of economic sectors toward knowledge based less polluting and dematerialized activities. We also outline the main challenges for Europe in terms of the education and training of R&D related employees.

3.1. Non stylized or new stylized growth period?

First we need to define how the benefits of investment are shared among companies and employees. The mechanisms for determining salaries in the NEMESIS model are based on a simple Phillips curve, in which the increase in real salaries based on growth, is linked to tensions in the labour market. This assumption does not hold when productivity gains are high and the time scale is a long one. We therefore adapted the original version of the Phillips curve by including a productivity effect.

In the reference scenario, a third of productivity gains from labour are passed on in real wages (a 10% increase in the labour productivity increases wages by 3.3%).

3.1.1. A non stylized growth period

From 2010, the two types of innovation that we have presented become active. R&D will produce its full effects: the global TFP gains will increase from 0.51 % in 2010 to 1.15 % in 2015, 1.98 % in 2020 and 3.21 % in 2030, and quality improvements will increase from 1.2% in 2010 to 3.85 % in 2015, 5.91% in 2020 and 7.89 % in 2030. Growth then is led by increased demand due to falling costs, and therefore reduced prices[7] (see Figure 3), and better quality (see Figure 4).

GDP growth (where slack is about 8.6% in 2030 in volume, Table 5 above) is enhanced mainly by demand in the form of final consumption and external balance:

Increased consumption stems from: employment growth, increased wages based onthe Phillips effect and the redistribution of productivity gains, reduced consumption prices; and quality effects. These phenomena

7. Productivity innovations reduce total production costs and then, by the mark-up behaviour of monopolistic competition the supply price. In the calibration that we adopted in NEMESIS, a 1% decrease in price enabled productivity improvements, leads to a rise of about 0.5% in demand (average price elasticity).

5. Macroeconomic Results for Europe*

	2015	2020	2025	2030
Demand.				
– Final Consumption	4.61	7.29	9.23	10.61
– Public Consumption	0.65	0.66	0.68	0.69
– Total Investment	3.04	4.34	5.35	6.08
- Firms' Investment	2.48	3.60	4.47	5.11
– Intra European Trade	3.09	5.37	7.14	8.45
– Extra European Imports	1.22	-0.10	-0.71	-0.41
– Extra European Exports	2.45	6.32	8.89	9.94
– Gross Domestic Product	3.48	5.85	7.52	8.56
Employment	2.44	3.64	4.51	4.86
Research and Productivity.				
– Research and Development	76.51	80.90	83.99	86.49
- private sector	90.98	97.34	101.94	105.56
– Research Intensity**	2.99	3.01	3.01	3.01
*- private sector***	2.07	2.09	2.10	2.11
– Total Factor Productivity	1.15	1.98	2.67	3.21
– Quality Indicator	3.85	5.91	7.15	7.89
– Knowledge Indicator	35.04	58.82	74.45	83.77
Other.				
– Real Disposable Income	5.14	7.71	9.50	10.87

* in % Deviation w.r.t. the Baseline except Research Intensity
** Absolute value in scenario

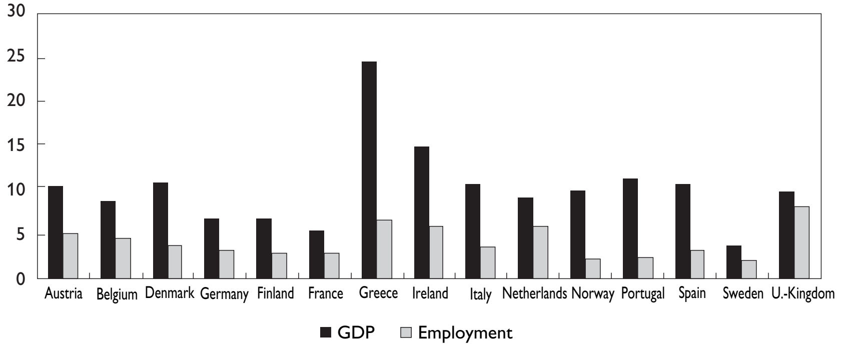
combine to produce consumption growth of 10.61% over the baseline, i.e. more than GDP increase. In other words, consumption in the principal booster to growth.

Exports increase as a result of lower prices and increased quality. This translates into a aslack for the exports of about 10% in 2030, which is significantly more than the GDP increase. In other words, exports are the second pillar of growth.

The other components of internal demand, production goods and investment, increase by much less; the reason is the productivity growth. Therefore, from a macro economic point of view, investment increases by only 5.11% in 2030.

It should be noted that, over the long term, the capital coefficient tends to fall, which does not fit with the stylised facts that capital/output ratio is constant in the long term. In other words, in our model growth is “non stylised”

Graphique 3. GDP and employment in European countries in 2030*
for NAP + FP Scenario



Source: * As a % compared to the trend-based count.

3.1.2. A re-stylised growth?

However, we are describing here, a period in which R&D effort is constantly increasing, i.e. a situation where there is no stable trajectory. This "non-stylised" growth is based on the knowledge increases which are higher than the rise in GDP. This produces a substitution effect between the two accumulation variables: physical capital and knowledge. If these two variables are accounted for (as, for example, in Rebelo's,1991, AK model), this would produce "re-stylised" facts with a constant new capital coefficient.

By 2030, Europe will have created 6.8 million jobs over the period, 2.4 million of which will be linked to research. The non-research employment figures are relatively low (up by 3.14% in 2030) as growth is partly based on significant productivity gains.

3.1.3. Results for countries

Overall, the macro-economic mechanisms for individual countries are the same as for Europe as a whole; they vary only according to the size of the RTD effort. The effect of the increase in R&D will be differentiated depending on individual country's characteristics, but the size of the effort will determine the gains or losses in each country's relative competitiveness. On the contrary of what was observed in the sowing period, now the countries with the most ambitious NAP will show greater relative competitiveness.

Greece, which has the most ambitious action plan for 2010, displays the highest GDP growth in 2030 at 24.55%. Many countries show GDP gains in 2030 of only some 10%, as can be seen from Table 6.

6. GDP and Employment in European Countries*

	Total Employ.		Research Employ.		GDP	
	2010	2030	2010	2030	2010	2030
Austria	46	203	33	58	1.2	10.44
Belgium	58	182	41	77	1.23	8.54
Denmark	25	105	25	45	1.1	10.78
Germany	298	1095	219	452	0.96	6.75
Finland	14	69	19	41	0.82	6.84
France	256	702	194	346	1.06	5.48
Greece	40	195	44	77	4.02	24.55
Ireland	22	116	48	84	2.2	14.95
Italy	164	658	179	323	1.6	10.74
Netherlands	89	381	60	119	1.15	9.09
Norway	20	48	32	47	1.39	9.99
Portugal	14	88	17	33	1.63	11.35
Spain	104	403	95	165	1.48	10.6
Sweden	13	94	4	22	0.48	3.75
U.K.	686	2502	286	526	2.09	9.77
Europe	1849	6841	1296	2415	1.36	8.56

*: Employment in thousands, GDP in % deviation versus baseline

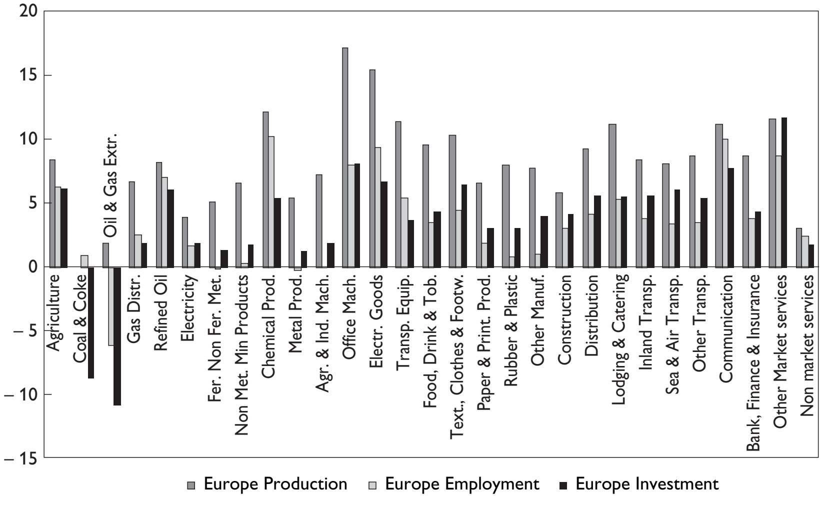
The smallest GDP gain is in Sweden with 3.75%, with increased R&D intensity of only 0.25 in 2030, or compared to the European average of 1.03 GDP points.

3.2. Sectoral restructuring: An acceleration of history

The evolution of sectors varies widely with some producing a major contribution to European GDP, and creating many jobs, while others suffering from productivity gains of other sectors. Sector evolution is complex and is based on the R&D efforts in the sector combined with intersectoral dynamics and the demand for goods and knowledge spillovers. Sectors are also differently affected by sharp increases in final consumption and external trade.

As the β coefficient increases with R&D intensity, we can deduce that sectors where R&D intensity is more important will show the best self-dynamic. The inter sectoral dynamic will play also its role, sectors that

Graphique 4. Production, employment and investment in sectors in Europe in 2030* (NAP + FP Scenario)



* As a % compared to the trend-based count.

make production goods will be disadvantaged, because progress in productivity will reduce their addressed demand.

– R&D-intensive sectors, including the chemical industry, office machinery, electrical goods and transport equipment[8], present the best results for the reasons already quoted. All these sectors show increased production: in 2030 the slack]is between 11.41% for transport equipment and 17.15% for office machines. Growth is explained by a simultaneous increase in internal demand and in external balance, due to decreased prices and quality enhancements.

– The consumption goods and household investment goods sectors are relatively R&D intensive and benefit from increased domestic purchasing power that results from greater employment, the Phillips curve, which increases real wages, and the redistribution of productivity gains in salaries. Quality effects and decreasing prices due to R&D, are also important and result in consumption driving growth. Households' investment (dwellings, cars, domestic equipment) is also boosted by the increased purchasing power.

– Those production good sectors that are not R&D intensive will suffer from the productivity gains produced by R&D in other sectors: the reduced addressed demand will not be compensated by a self dynamism

8. The other commercial services sector, which includes commercial research services, is another R&D intensive sector.

of the sector. Such sectors include Agriculture and Industrial machines, where job losses across Europe will be 0.06%, in contrast to 4.86% of overall job creation). Metal products, non ferrous and non metallic mineral products will also suffer: employment remains stable or decreases slightly.

We can see that a policy of intensifying R&D efforts tends to accelerate the natural course of redeployment: transformation industries where employment is already declining in the past and in the business as usual scenario, will be disfavoured by such a policy that plays the role of an "attractor" in the history of industrial mutations.

3.3. The road to a new qualitative, less polluting and dematerialised economy

Three main characteristics distinguish the NAP scenario from the 'business as usual' scenario: industrial restructuring, better quality of goods; and the importance of research employment.

The better quality of goods is a result from R&D efforts. We have shown that the results of 8.56% over GDP in volume, underestimates real growth because quality effects are not taken into account. We can give an upper bound to this overall quality effect on GDP of 7.89% in 2030 (see Table 4), but it is difficult to give a precise estimate for GDP, which could be between 8.56% (increase in volume) and 16.45% if all quality effects are included.

If we add to this the increase in TFP, which reduces materials requirements, the R&D policy is shown to produce a major dematerialization of economy. In terms of CO_2 emissions, we can see that there is a decrease of 0.85% in 2030 in Europe, despite the 8.56% GDP growth. Thus there are significant reductions in emissions per unit of GDP, -9.41%.

Besides dematerialization of economy is also perceptible to the strong increasing created jobs in research

3.4. A main challenge for Europe: researchers' education and training

In terms of research linked jobs in 2030, we can see that 2.4 millions more jobs will be created by the Barcelona objective. To this figure we can add the number of jobs that we would expect to be created in the business as usual scenario, merely to maintain R&D intensity in the 2004-2030 period (2% of GDP). GDP growth pulls R&D expenses and to maintain efforts in the business as usual scenario, some 1.5 million research jobs must be created in the run up to 2030. Based on the Barcelona objective, this would be 3.9 million new jobs.

7. CO_2 emissions (% dev. from benchmark count)

	CO2 Emissions in 2030
Austria	-1.76
Belgium	-2.16
Denmark	-1.46
Germany	-0.47
Finland	0.52
France	-1.64
Greece	3.75
Ireland	-1.31
Italy	0.73
Netherlands	-2.29
Norway	2.91
Portugal	1.26
Spain	-0.11
Sweden	-1.00
U.K.	-2.57
Europe	-0.85

Not all these jobs will be purely research employment, but it is estimated that about 1.95 million researchers must be educated and trained, which will be a major challenge for Europe, particularly if we must consider all the graduated who must be trained in order to go with the researchers.

The new European economy envisaged by the Lisbon Strategy will have traditional activities replaced by knowledge based qualitative dematerialized economy.

4. Conclusion

The implementation of European countries' NAP will be a difficult period but should be followed by a bountiful crop of an additional 0.35% to 0.5% of annual growth and more than 7 million jobs. The implementation of these plans will need appropriate accompanying measures:

The sowing period involves private R&D investors and will produce an important rise in production costs but no immediate major effects in terms of innovation, productivity and quality gains. This demand oriented phase will produce increased GDP, but accompanied by inflationary pressures due to the extra financing needed for R&D efforts. Deficits will deepen and the competitiveness of European countries will be reduced. How to implement accompanying measures, for instance a new financing engineering, especially adapted to that sowing period?

The period of reaping, in spite of its gorgeous aspects, masks an acceleration of restructuring: not all sectors will benefit from this strong R&D policy, and accompanying measures must be designed and planned to support the traditional industries and the sectors producing goods that will suffer from productivity gains.

The main challenge will be the education and training of 3.9 million more employees in research activities, half of which being researchers.

Using this same framework, we have conducted several exercises on various implementation policies and sensitivity analyses, the details of which are not included here. The forward study deal with the role of the EC's 7th framework programme in the Lisbon strategy, and the search for the most appropriate instruments to achieve R&D programs.

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