Impact of the Crisis on Research and Innovation Policies

Study for the European Commission DG Research, Directorate C – Research and Innovation under the framework contract Lot 2

This study was written by Kincsö Izsak (Technopolis Group), Paresa Markianidou (Technopolis Group), Ruslan Lukach (Idea Consult) and Annelies Wastyn (IDEA Consult). Laura Roman (Technopolis Group) assisted the data collection.

The authors would like to thank Vladimir Balaz, Anton Geyer, Katre Eljas-Taal, Attila Havas, Cecilia Johannson, Nikos Maroulis, Tom Martin, Alasdair Reid, Miriam Ruiz, Laszlo Szilagyi, Klaus Schuch, Miguel Taborda and Jacek Walendowski for their comments and country-specific insights.

Special thanks goes to Marco Vivarelli for reviewing the whole report and providing us useful comments.

We also would like to thank to Silvia Luber from the European Commission who followed up this study.

Disclaimer: The information and views set out in this study are those of the authors and do not necessarily reflect the official opinion of the European Commission or the Member States.

Please cite this study as Izsak, K., Markianidou, P., Lukach, R., Wastyn, A. (2013). The impact of the crisis on research and innovation policies. Study for the European Commission DG Research by Technopolis Group Belgium and Idea Consult.

Executive Summary

Five years since the start of the financial and economic turmoil in Europe finding the optimal response to the crisis is still pertinent. The urgency to implement better growth enhancing policies is still felt across Europe. The objective of this study is to better understand the qualitative as well as quantitative dimensions of the impact of the crisis on research and innovation policies and activities in the EU Member States.

The 2008 global financial crisis and the economic and public sovereign debt crisis have in its aftermath shaken research and innovation activities and policies in Europe. The crisis has had a negative impact on two important inputs of research and innovation (although to different extents across EU Member States): public R&I budgets and on the availability of human resources for R&I.

Diverging patterns in research and innovation performance

The 2008 crisis had a profound effect on both general and knowledge intensive activities. Both general and knowledge intensive activity indicators showed a downturn in: Austria, Croatia, Cyprus, Czech Republic, Greece, France, Italy, Latvia, Lithuania, Netherlands, Portugal, Romania, Slovenia, Spain and United Kingdom.

In the cases of Belgium, Denmark, Estonia, Finland, Hungary, Ireland, Luxembourg, Poland, Slovakia and Sweden only the general economic indicators appear to have been affected by the crisis – but not the knowledge intensive activities. Countries with a robust knowledge intensive industrial structure appeared to be less sensitive to the financial and general economic downturn (the Nordic Countries, for example).

Several countries have not shown any statistically significant indications of structural change since the 2008 economic crisis. These countries include: Germany - due to its strong economic fundamentals, well established innovation system and advanced sectoral specialisation; Malta – a small open economy with the sectoral specialisation less sensitive to the factors behind the 2008 crisis; Norway - strong economic fundamentals based on its resource abundance; and Switzerland - due to its strong and robust financial sector and advanced sectoral specialisation.

Interestingly, countries were affected by the 2001 recession, such as Austria, Belgium, France, Ireland and the Netherlands appear among those that have managed to keep their private sector's R&D growing or at a stable level. Also, countries that appeared not to have been affected by the crisis in terms of their economic performance indicators show positive post-crisis dynamics in their R&D inputs. At the same time their R&D outputs and commercialisation enablers did suffer from the crisis, which is an indication that the *tendencies influencing innovation activities are not bounded by the national borders.*

The cases of Greece and Spain, apart from their reputation of being the hardest hit by the crisis, are also interesting as examples where the predominantly positive pre-crisis dynamics in R&D inputs and outputs has changed into overall decline in the post-crisis period.

Pressure on public research and innovation budgets

On the positive side, many of the countries examined here regarded research and innovation as a way out of the crisis and made real progress to protect public R&I activities. Although there was a countercyclical trend in 2008-2010 in terms of research and innovation public funding, maintaining funding levels has become difficult since 2011. Securing funding for research and innovation policies has become one of the most relevant challenges.

Comparing the trends in public research and innovation funding (based both on GBAORD and TrendChart inventory funding figures) the negative evolution is striking. Although research and innovation policies were protected right after 2008 until 2010, maintaining funding levels have become difficult most recently. In the period 2008-2009/2010, only **Greece, Romania and Latvia** showed more than a 10% decrease in R&I budgets. This changed dramatically when looking at the 2011-2012/2013 period when **Bulgaria, Hungary, Ireland, Italy, Latvia, the Netherlands Portugal, Spain and the UK** experienced negative trends. The fall in GBAORD figures in the cases of Greece, Latvia, Romania and Spain were especially severe.

Another noteworthy finding is that the *decline in government R&D expenditures did not always coincide with a general decline in other government expenditures*. This indicates that the public R&D expenditures budgets are not necessarily considered 'protected funding lines' in all countries as advocated. Depending on the individual countries' priorities one can observe that public R&D funding decreased more than other budget lines.

One consequence of the changes in national public research and innovation funding was that the importance of other sources has increased. The pressure on public funding led to more private-public partnerships in implementing research and innovation programmes. The emphasis therefore shifted towards the Structural Funds or other EU and international funding as more stable sources of financing.

Increasing challenge on retaining skilled human resources

In many of countries such as Greece, Ireland, Latvia, Portugal and Spain the tight public R&I budgets have resulted in another increasing problem: how to retain skilled human resources that can build a more innovation-oriented society. Many researchers and parts of the skilled labour force have been leaving due to the instability of the system, low career prospects and salary cuts. Although there are no exact statistics of the migration of highly skilled people, but the analysis based on the Eurostat and OECD data shows that indeed this might be an area for concern.

Comparing migration patterns with public spending on human resources points to gaps both in terms of general human resource development and with regard to higher education expenditure on research.

Countries where a negative net-migration occurred and where brain drain has been reported are also among the ones that decreased public spending on general human resource development. Greece, Ireland, Latvia, Lithuania, Poland, Portugal and Spain saw an overall decrease in public funding that amounted to more than 10% between 2008 and 2012 (EUA, 2012) together with other countries such as the Czech Republic, Italy, Hungary and the Netherlands.

This trend is coupled with **a decrease in higher education expenditure on R&D (HERD) in countries such as Ireland, Italy, Portugal, Romania, Spain and the UK**. This is alarming as it can further aggravate the situation of stable human resources. However, these countries showed a linearly increasing trend in HERD between 1990 and 2008; this increase reversed in 2009.

Innovation policy mixes

The crisis did not change substantially the national research and innovation policy mixes, although it amplified attention in areas such as:

- Turning towards loans, guarantees and state backed venture capital as alternative finance;

- Extended use of R&D tax incentives;
- More pressure on commercialising research results;
- Targeting/prioritising research and innovation programmes.

Despite of several hot topics that have become popular in the aftermath of the crisis such as support to 'high growth enterprises' or demand-side innovation policies, the research and innovation policy mixes show more rigidity to changes than might be expected.

Although some of countries turned towards alternative policy instruments to maintain research and innovation activities, the review of measures and evaluations *reports also reveal that some of the long-standing and stable innovation policy measures that continued in a consequent manner have been important to stimulate innovation. In addition, innovation vouchers as a flexible instrument have been also found as important to keep companies engaged in innovation activities in times of crisis.* The most recent innovation policy country reviews have repeatedly cited the relevance of the *Structural Fund* programmes. These brought a certain kind of stability in the innovation system they were typically on-going funds.

Loans, guarantees and venture capital

As the review of the research and innovation policy measures during the 2009-2013 period shows, one trend has been that national governments provided strengthened support through loans, loan guarantees and venture capital measures. Private venture capital communities also urged greater public sector involvement at a time when it was difficult to generate investment and raise capital. Loan guarantees have indeed been used successfully in some cases to stimulate innovation in times of financial crisis. A renewed target of these policies have become the so-called 'young innovative companies' that can reach fast growth and be an engine of the economy.

While loans, guarantees and venture capital schemes seem to be viable and cheaper alternatives to support innovation in times of tight public budgets, one must be cautious. We would argue that a balanced development of the policy mix portfolio is necessary. Loans, guarantees and venture capital funds can work when there are already ideas to commercialise – which might already be present in countries closer to the technology frontier – but play a different role in countries with a less developed innovation culture. In these countries if the measures are not complemented by strong measures to support innovation culture and skills, shifting towards more loan-based instruments won't reach the intended impact.

As the country cases show *loan-based instruments are not a straightforward solution to finance innovation* in Greece, Portugal or Spain. In Greece there was an attempt to shift towards loans but this did not work due to the general conditions of the banking system. Similarly, in Portugal the operational difficulties hamper the ability to get guarantees and limit businesses willing to invest in R&D and innovation in obtaining support.

R&D tax incentives

R&D tax incentives are among the measures that have particularly increased in popularity during the crisis. In some countries R&D tax incentives have already been used for a long time and while no robust empirical evidence exists there is anecdotal evidence of a positive impact on R&D expenditures particularly in the short term. While the effectiveness in stimulating business R&D is not yet proven, R&D tax incentives have been claimed to be an appropriate choice during recession times given the available empirical evidence that points towards a positive impact of tax incentives on R&D expenditures in the short term. Evaluation studies conducted in France, Ireland and Portugal in the period 2009-2012 found positive effects.

New paths for research and innovation policies - country patterns in the EU

The latest economic reviews convey a positive message about the process of fiscal consolidation in the Eurozone in the upcoming years; however, they warn that the on-going recovery may remain fragile and sluggish unless measures are taken to raise investments to support the economy (EC, 2013). As the country analysis shows, there are several common patterns that will shape the national research and innovation policy and policy mix in the upcoming period. This analysis identified three possible future scenarios:

Table 1: Scenarios for research and innovation policies in 2014-2020

Scenarios	**Countries**
"Modus operandi"	Czech Republic, Hungary, Lithuania, Malta, Poland, Slovakia
"Empty pocket"	Bulgaria, Cyprus, Greece, Italy, Latvia, Portugal, Romania, Slovenia, Spain
Long-term commitment to R&I policies	Austria, Denmark, Estonia, Finland, France, Germany, Ireland, Luxemburg, the Netherlands, Norway, Sweden, Switzerland, UK

Some of the key questions that will guide and influence the future research and innovation policies are:

- What are alternative ways to finance innovation?

This question is being discussed across all countries for different reasons: in the countries hit hard by the crisis alternative financing mechanisms could bring relief to the public budget purse; in countries where research and innovation policy is being financed mainly by SF it could offer alternatives for phasing out and relying more on domestic sources. Also, a more buoyant venture capital market could foster entrepreneurship.

- How to foster new specialisations in higher technology level industries and how to raise the growth dynamics of innovative firms? How to raise more demand for innovation?

The crisis amplified the problem that many countries have only a weak basis of new technology-based or (emerging industry) firms. Although it is relevant across all EU Member States the most recent research and innovation strategies for instance in Denmark, Finland, France, the Netherlands and the UK have taken steps to anticipate new growth areas and create new specialisation patterns in high-tech innovative industries.

- How to stop brain drain?

In several countries where the economy was hit hard by the crisis, the problem with the supply of a qualified labour force for R&D and innovation sector has become particularly acute due to brain drain. This is currently happening in Greece, Italy, Portugal and Spain (where researchers also face salary cuts); it is also a serious issue in Hungary, Latvia and Slovenia where many talented people leave to find better prospects and high-level job abroad.

- How to harness the potential of globalisation?

Globalisation offers a new source and potential new demand for innovation. Solving societal challenges and developing new solutions that can be used world-wide is already part of strategic thinking in many countries - for example in France, Finland, Denmark, Sweden and the UK. Future research and innovation policies show some

shifts in this respect, where internationalisation and positioning the innovation system globally gets stronger attention. In countries like Sweden or France internationalisation efforts are also linked to cluster policies.

- How to better use Structural Funds smarter, how to live without Structural Funds and how EU Funds support research and innovation?

In many countries no substantial changes in innovation performance are expected as compared to previous programmes. Despite good intentions in smart specialisation strategies, and in many cases serious on-going work, it is questionable that the concrete implementation will make a real change. In many countries, there are voices of 'modus operandi' meaning that it is not expected that the new programming period will bring the crucial, important changes that are necessary. Related to the previous question, Member States now relying too heavily on Structural Funds must start planning how to find different mechanisms to finance research and innovation. There is a real threat that the overreliance of European funds will undermine the future of a more competitive and sustainable economy.

Prospective analysis

The results of this analysis show that the effects of policy changes leading to an increase in GBAORD are more likely to be associated with an increase in business R&D, R&D personnel and venture capital financing.

The link between the GBAORD increase on patenting appears to be mixed with multiple positive and negative results observed. It appears that an increase in GBAORD is likely to be accompanied by an increase in patenting in the "modus operandi" group of countries, and by a decrease in the countries that were hardest hit by the crisis. Furthermore, such a decreasing pattern is also observed in most old Member States indicating the current level of state support to R&D and innovation has probably exhausted its patenting stimulating potential.

A positive shift in BERD is likely to result in a positive reaction in the R&D personnel variable and in patenting. The positive effect of shifts in BERD on patenting is observed in different country groups, which allows us to argue that the policy actions that stimulate private R&D and not necessarily involve increase in government R&D are still likely to encourage patentable innovation activities.

Venture capital financing appears to react in a mixed way to positive change in business R&D. We expect positive shifts in business R&D to be accompanied by positive shifts in VC financing in countries least affected by crisis (such as Germany and the Nordic countries). For the rest of Member (and Associate) States no common pattern has emerged.

In general, the following analysis allows us to argue that the policy mix shifts towards measures stimulating private R&D and creating a favourable environment for more entrepreneurial activity are more likely to provide stable positive effects on most R&D inputs and outputs. The measures that are mostly accompanied by the increase in public R&D are more likely to lead to positive dynamics in general R&D inputs and not necessarily in R&D outputs.

Table of Contents

Executive Summary **3**

Table of Contents **8**

1. Research questions and methodological background **9**

2. Performance in research and innovation in the aftermath of the crisis **11**
2.1. Different experiences of the recent economic crisis *11*
2.2. Different RDI performance patterns before and after the 2008 crisis *14*
2.3. Summary of findings *18*

3. Research and innovation policies in the aftermath of the crisis **19**
3.1. Pressure on public research and innovation budgets *20*
3.2. Increasing challenge to preserve skilled human resources *24*
3.3. Consolidation and streamlining *26*
3.4. Quest for an innovation-based growth but no substantial change in the policy mixes *28*

4. Measures and alternatives to foster innovation-based growth **31**
4.1. Revisiting research and innovation in 'crisis' packages *31*
4.2. Looking for alternative financing mechanisms: loans, guarantees and support to venture capital *34*
4.3. R&D tax incentives during the crisis: a viable tool to support business R&D and innovation in the future? *43*
4.4. Consequent policy-making and flexible policy measures *50*
4.5. European dimension in enhancing innovation-based growth *52*

5. Country patterns in policy approaches and scenarios for the future **54**
5.1. Review of the latest policy trends *54*
5.2. Looking into the future – a statistical prospective analysis *59*

6. Comparative case studies **66**
6.1. Greece, Portugal, Spain – innovation in countries seriously hit by the crisis *66*
6.2. Czech Republic, Hungary, Poland – and the 'Structural Funds' driven Central-Eastern European country group *76*

References **82**

Appendix A Methodological notes **86**

Appendix B List of R&I measures with an objective to stimulate business innovation introduced in the crisis period or linked to the crisis **88**

Appendix C R&D Tax incentives **90**

1. Research questions and methodological background

Five years since the start of the financial and economic turmoil in Europe, the quest for finding the optimal response is still pertinent.

Although innovation has been seen from the start as a way out of the crisis, the stability of research and innovation funding has become a major issue. The crisis period saw increased efforts on the part of the R&I stakeholders to maintain R&I budgets and 'protect' them from expenditure cuts, as fiscal consolidation measures took their toll on R&I budgets. However, this has not always been successful. The general landscape in the EU points to diverging paths: the values of public R&D funding have increased in some leading innovating countries but decreased severely in others.

The urgency to find and rapidly implement better growth enhancing policies is felt in all Member States. Several new initiatives are underway to implement structural reforms that can enhance national innovation performance and Member States apply different policy approaches. In order to have a better understanding of the qualitative as well as quantitative dimensions of the impact of the crisis on research and innovation policies of the EU Member States, this study addresses the following key questions:

- How has the economic and financial crisis that started in 2008 influenced research and innovation activities in Europe? (Chapter 2)
- What are the current trends in research and innovation policies in EU Member States that are directly or indirectly related to the economic and financial crisis? (Chapter 3)
- Are there specific EU or national initiatives that have been particularly effective in fostering innovations in spite of the crisis? (Chapter 4)
- To what extent will these trends influence the innovation performance and the growth prospect of individual Member States in the next 10 years? (Chapter 5)
- What implications can be derived for future EU research and innovation policy initiatives? (Chapters 5 and 6)

Analytical approach

The geographical scope of the study covers the EU28 Member States, Norway and Switzerland (referred as EU28+2 hereafter).

This analysis relies on the inventory of INNO Policy TrendChart and ERAWATCH (referred as the **TrendChart inventory** hereafter) concerning research and innovation policies and policy measures, which have been complemented with desk research and interviews with country experts. In addition, it uses a **selection of performance indicators** with the aim of analysing statistical trends in research and innovation activities. The two databases on innovation policy measures and innovation performance allow delivering answers to the questions on how research and innovation activities evolved, how national research and innovation policies changed as a result of the crisis and where, and how have research and innovation policies successfully responded to the new challenges.

Inventory of research and innovation policy measures

The TrendChart inventory includes a total of 2.321 measures, including overarching policy measures (mini-mixes) and sub-measures. A policy measure is defined as one that:

- mobilises resources (financial, human, organisational) through publicly (co-) financed research and innovation programmes or initiatives; and/or
- funds the generation or diffusion of information and knowledge (studies, road-mapping, technology diffusion activities, advisory services, public-private partnerships, etc.) in support of research and innovation activities; and/or
- promotes an institutional process (legal acts, regulatory rules) designed to explicitly influence the undertaking of research and innovation by organisations;
- is normally implemented on an on-going (multi-annual) basis, rather than being a one-off 'event' or a single 'project'.

Statistical indicators

The main indicators considered in this analysis provide information to obtain an overall picture on and the means to assess the impact of the crisis in EU Member States and include the following themes:

- Research and Development (R&D);
- Science and Technology (STI) (input and output);
- Macro economic conditions;
- Financial markets.

The analysis of performance in research and innovation in this study is implemented via two main approaches. The first approach involves analysis of the structural changes in the time series data base on quarterly and monthly indicators, which mainly represent the general economic tendencies at the national and sectoral level. The second approach examines a number of annual variables, which due to their low frequency cannot be used for the structural breaks detection, but still can provide some (mostly visual) information about the RDI performance dynamics before and after the 2008 crisis. (For a complete list please see Appendix A.)

Time-series analysis: Structural changes detection

The retrospective analysis of innovation performance is based on a 'historical' time series. The aim will be to identify key trends and structural breaks in trends. The analysis is at country level, for all EU 28+2 countries covering a broad time period. The structural breaks analysis allows us to observe breaks in the dynamics of our variables. A structural break is defined here as an unexpected shift in a time series. Although it is not possible to indisputably establish a causality link between the crisis and R&D expenditures and policy changes and R&D expenditures (thus whether or not the policy led to a change in R&D expenditures), we still can statistically test whether or not the outcome's evolution over time has suddenly changed in a given moment (i.e. whether a so-called structural break in the time series has occurred). The results of this structural changes analysis are discussed in Appendix A Methodological notes, and the underlying figures and diagrams are presented in the Empirical Annex.

Time-series analysis: RDI performance analysis

The RDI performance analysis has been carried out based on the descriptive illustrations of the recent dynamics in the corresponding performance measures. Its main purpose is to detect the visible behaviour patterns before and after the onset of the 2008 economic crisis.

Furthermore, the RDI performance results are combined with the results of the structural breaks analysis to provide the overall view at the crisis impact patterns.

2. Performance in research and innovation in the aftermath of the crisis

The crisis had a severe impact on the real economy resulting in tighter credit conditions, cutback in demand and trade, and in a decrease in access to finance. It triggered a shift in many business strategies from long-term competitiveness to short-term survival.

Previous literature has shown that a pro-cyclical relationship exists between the general economic performance indicators and the variables related to the country's performance in research, development and innovation (RDI). According to the OECD's data analysis (2009) on the effects of the economic crisis on innovation activities, innovative firms tend to scale back their R&D expenditures and investments in risky projects in times of crisis. This is frequently accompanied by a drop in patenting activities, new trademark applications and a drop in venture capital financing.

At the micro-economic level the above observations have been supported by the data from the Community Innovation survey (Archibugi et al., 2013), showing that as the companies were decreasing their R&D efforts in the aftermath of the crisis, only a small part of them managed to keep their R&D activities at the same level.

Filippetti and Archibugi (2011) further show that a large number of firms have managed to maintain their investment for innovation. At the same time the number of firms able to continue with expanding their R&D has dramatically dropped and the number of firms that have scaled down their R&D has substantially increased. In terms of the geographic spread of these effects it has been observed that the most affected countries were European 'catching-up countries', in particular the New Member States in Central and Eastern Europe.

In the forthcoming analysis we employ methods that allow us to conclude about the effects of the crisis on RDI performance in a more reliable manner. The structural break analysis serves exactly this purpose as it provides a statistical test for the observed structural change in the time series dynamics of performance indicators – which may be attributed to the onset of the recent economic crisis.

2.1. Different experiences of the recent economic crisis

In Table 2 below we summarise the structural break analysis results obtained for individual countries. Based on the statistical tests for a multitude of different indicators we have formulated two general statements which serve as the qualitative answers to the following questions:

- Did the economic activity indicator show a sign of structural changes corresponding to the recession of 2001 (a so called end of the Internet boom);
- Did the economic activity show a sign of structural changes corresponding to the recession of 2008 (the 'current' economic crisis);
- Are there sings of structural changes in the aftermath of the crisis based on the available monthly data;
- What are the time moments of structural breaks identified by the statistical procedure.

Furthermore, we considered the signals produced by two general types of indicators: indicators corresponding to general economic activities and indicators of activities in the knowledge intensive sectors. For detailed results of the structural changes analysis we refer to the Empirical Annex.

In the results in Table 2 we have formulated the following:

- The majority of indicators in most countries indicate a negative structural shift corresponding to the 2008 financial and economic crisis.
- The series indicate that the structural shift driven by the 2008 crisis took place in the 2nd and 3rd quarter of 2008.
- The countries that experienced a structural shift corresponding to the 2001 recession are mostly the Old Member States: Austria, Belgium, France, Ireland, Italy, the Netherlands, Portugal and United Kingdom. Only Poland among the New Member States showed signs of slowdown in 2001.
- The 2001 shift was more likely to have occurred in the knowledge intensive activities indicators rather than general economic areas. For example, France, Italy and UK experienced the 2001 slowdown only in the knowledge intensive indicators and not the general indicators.
- The 2008 crisis had a profound effect on both general and knowledge intensive activities. Both general and knowledge intensive activity indicators showed a downturn in: Austria, Croatia, Cyprus, Czech Republic, Greece, France, Italy, Latvia, Lithuania, the Netherlands, Portugal, Romania, Slovenia, Spain and United Kingdom.
- None of the countries showed a pattern of slowdown only in knowledge intensive activities. However, in the cases of Belgium, Denmark, Estonia, Finland, Hungary, Ireland, Luxembourg, Poland, Slovakia and Sweden only the general economic indicators appeared to have been affected by the crisis. There is a double explanation possible for this: first, the countries with relatively underdeveloped knowledge intensive industries (e.g. New Member States) are less likely to experience large shifts there. Second, the countries with a robust knowledge intensive industrial structure appeared to be less sensitive to the financial and general economic downturn (for example the Nordic Countries).
- Finally, several countries did not show any statistically significant indications of structural changes as a result of the 2008 economic crisis. These countries include: Germany (likely due to its strong economic fundamentals, a well established innovation system and advanced sectoral specialisation), Malta (very small open economy with the sectoral specialisation less sensitive to the factors behind the 2008 crisis), Norway (strong economic fundamentals based on its resource abundance) and Switzerland (due to its strong and robust financial sector and advanced sectoral specialisation).

Table 2: Overview of the economic and RDI performance structural changes

Country	Output indicators	Detected structural breaks (quarterly)		Structural breaks (monthly)	Year(s) the crisis hit
		2001 'Internet bust'	2008 Financial Crisis		
Austria	General	x	x		20011q1, 2008q2
	Knowledge intensive	x	x		2002q3, 2007q3

Country	Output indicators	Detected structural breaks (quarterly)		Structural breaks (monthly)	Year(s) the crisis hit
		2001 'Internet bust'	2008 Financial Crisis		
Belgium	General	x	x	sign of recovery in 2012	2000q3, 2008q2
	Knowledge intensive	x			2001q3
Bulgaria	General		x	2008	2008q2
	Knowledge intensive		x		2009q1
Croatia	General		x		2008q2
	Knowledge intensive		x		2008q1
Cyprus	General		x	2008	2008q3
	Knowledge intensive		x		2008q3
Czech Republic	General		x	2008	2008q3
	Knowledge intensive		x	2008	2008q4
Denmark	General		x		2008q1
	Knowledge intensive				
Estonia	General		x		2008q1
	Knowledge intensive				
Finland	General		x	2008	2008q1
	Knowledge intensive				
France	General	x	x		2001q1, 2008q2
	Knowledge intensive		x	2008	2008q2
Germany	General				
	Knowledge intensive				
Greece	General		x		2008q3
	Knowledge intensive		x		2008q3
Hungary	General		x		2007q1?, 2008q2
	Knowledge intensive			2008 in ICT	
Ireland	General	x	x		2001q1, 2008q2
	Knowledge intensive	x			
Italy	General		x	2008	2008q3
	Knowledge intensive	x	x		2002q3, 2008q1
Latvia	General		x		2008q2
	Knowledge intensive		x		2008q2
Lithuania	General		x		2008q2
	Knowledge intensive		x	upshots in 2010	2008q3
Luxembourg	General		x		2008q2
	Knowledge intensive				

Country	Output indicators	Detected structural breaks (quarterly)		Structural breaks (monthly)	Year(s) the crisis hit
		2001 'Internet bust'	2008 Financial Crisis		
Malta	General				
	Knowledge intensive				
Netherlands	General	x	x		2001q3, 2008q2
	Knowledge intensive	x	x		2001q3, 2007q3
Norway	General				
	Knowledge intensive				
Poland	General	x	x		2002q3, 2008q1
	Knowledge intensive			2010 in ICT	
Portugal	General	x	x		2001q1, 2008q1
	Knowledge intensive		x		2008q4
Romania	General		x	2006 and 2008	2008q3
	Knowledge intensive		x		2008q3
Slovakia	General		x		2008
	Knowledge intensive				
Slovenia	General		x	2006 and 2008	2008q3
	Knowledge intensive				
Spain	General		x	2008	2008q2
	Knowledge intensive		x	2008	2008q3
Sweden	General		x		2008q1
	Knowledge intensive				
Switzerland	General				
	Knowledge intensive				
United Kingdom	General		x		2008q1
	Knowledge intensive	x	x		2001q1, 2008q1

2.2. Different RDI performance patterns before and after the 2008 crisis

Before the 2008 crisis

In the period preceding the onset of the 2008[1] financial and economic crisis most European countries experienced predominantly positive tendencies regarding the main R&D inputs (volume of business expenditures on R&D, employment and public outlays), outputs (represented by patents) and commercialisation enablers (venture capital and access to loans).

[1] At least between 2005 and 2008 and longer for indicators where more data is available.

These tendencies have been, however, exhibited differently by different countries:

- On average the R&D inputs grew in most countries, except Latvia (private R&D expenditures appeared to decline), Hungary (decrease in public R&D), Sweden (a clear constant level of private and public R&D and the R&D employment), and Malta (on average constant level across all indicators).
- The patent output declined in several Old Member States (Belgium, Denmark, Italy, Finland and UK). What is remarkable is that these declines appeared on the background of the growing or stable R&D inputs. This observation deserves further attention when discussing the post-crisis dynamics.
- Similarly the increases in the patent output were not necessarily accompanied by corresponding increases in R&D.
- Regarding the volume of venture capital financing, the pre-crisis situation looked positive overall for all countries. Venture capital was growing in the majority of cases and stable otherwise.
- While observing the index of the ease of access to loans, the pre-crisis picture cannot be characterised as overall positive or stable. In a number of countries the ease of access index was declining (Greece, France, Italy, Austria, Poland, Portugal and Lithuania). It appears that all of these countries (except Austria) are also the ones which had experienced the most difficult budgetary problem at national level. This also makes them also interesting subject for further investigation.

After the 2008 crisis

- After the onset of the 2008 economic crisis it was not surprising to see that in almost all countries the R&D outputs and enabler dynamics (such as venture capital funding and an index of ease of access to loans) became clearly negative. In case of patenting the decreasing numbers have been observed even before the 2008 crisis in some countries. This held for all European Member States.
- The dynamics of the R&D inputs and employment after the crisis was, nonetheless, different in some countries. Austria, Czech Republic, Estonia, France, Germany, Norway and Poland have continued to increase (or kept stable) their R&D inputs across all considered indicators. The resilience of performance in these countries can be attributed to two different compositions of factors. One the one hand, we have older Member States with mature and relatively large RDI systems. On the other hand, there are several new Member States with still developing innovation systems that enjoy substantial European support (e.g. via Structural Funds).
- Hungary, Ireland, Italy, the Netherlands, Portugal, Slovakia and Slovenia did exhibit a decline in government R&D expenditures, while private R&D and R&D employment have offered more resistance to crisis and have been increasing or have remained stable.
- The decline in government R&D expenditures in Italy, Hungary, the Netherlands, Ireland, Slovenia and Slovakia did not always coincide with a general decline in government expenditures. In Italy and the Netherlands, other government expenditures such as environment protection, agriculture, foreign economic aid, housing and community amenities, mining, public debt transactions, public health services, public order and safety, tertiary education and transport remained relatively the same in the period after the crisis (2007-2011). In Hungary a sharp decline in government expenditures with respect to agriculture and transport occurred. In Slovenia, public debt and transport expenditures increased. Ireland has a similar increasing pattern in public debt expenditures while expenditures in housing and transport sharply dropped after the crisis.

This allows us to conclude that the public R&D expenditures budgets are not necessarily considered as 'protected funding lines' in all countries. Depending on the individual countries' priorities one can observe that the public R&D funding decreased more than other budget lines.

- Looking at Nordic EU members, we observe that Denmark, Finland and Sweden all showed on average stable levels of BERD, GBAORD and R&D employment (while having declining outputs).

Table 3: RDI performance overview before and after the crisis

Country	RDI indicators patterns 2005 - 200x (where x represents the year of the crisis hit)						RDI indicators patterns 200x-2013 period (where x represents the year of the crisis hit)					
	BERD	GBAORD	R&D Employment	Patents	Venture capital	Ease of access to loans	BERD	GBAORD	R&D Employment	Patents	Venture capital	Ease of access to loans
Austria	↑	↑	↑	→	↑	↓	↑	↑	↑	↓	↓	→
Belgium	↑	↑	↑	↓	↑	→	↑	→	↓	↓	↓	↓
Bulgaria	↑	↑		↓		↑	↓	↓	↓	↓	→	→
Croatia	↑	↑	↑	↑		↑	↓	↑	↓	↓		↓
Cyprus	↑	↑	↑	→		→	↓	↓	→	→		↓
Czech Republic	↑	↑	↑	↑	→	↑	↑	↑	↑	↓	→	↓
Denmark	↑	↑	↑	↓	↑	→	→	→	→	↓	↓	↓
Estonia	↑	↑		↑		↑	↑	↑	↑	↓		↓
Finland	↑	↑	→	↓	↑	→	→	→	↓	↓	→	↓
France	↑	↑	↑	→	↑	↓	↑	→	↑	↓	↓	↓
Germany	↑	↑	↑	→	↑		↑	↑	↑	↓	↓	↓
Greece	↑	↑	→	→	↑	↓		↓	↓	↓	↓	↓
Hungary	↑	↓	↑	↑	→	→	↑	↓	↑	↓	→	↓
Ireland	↑	↑	↑	↑	↑	→	→	↓	→	↓	↓	↓
Italy	↑	↑	↑	↓	→	↓	↑	↓	↑	↓	↓	↓
Latvia	↓	↑	↓	→		→	↓	↓	↓	→		↓
Lithuania	↑	↑	↑	↑		↓	↑	↓	↓	→		→
Luxembourg	→	↑	↓	→		↑	↓	↑	→	↓		↓
Malta	→	→	→	→		→	↑	→	↑	→		↓
Netherlands	→	↑	→	→	↑	→	↑	↓	↑	↓	↓	↓
Norway	↑	↑	↑	→	↑	↑	↑	↑	→	↓	→	↓
Poland	↑	↑	→	↑	↑	↓	↑		↑	→	→	↓
Portugal	↑	↑	↑	→	↑	↓	→	↓	→	↓	→	↓
Romania	↑	↑	→	↑	↑	↑	↓	↓	↓	↓	↓	↓
Slovakia	↑	↑	↓	→		↑	→	→	→	↓		↓
Slovenia	↑	↑	↑	↑		→	↑	↓	↑	↓		↓
Spain	↑	↑	↑	↑	↑	→	↓	↓	↓	↓	↓	↓
Sweden	→	→	→	↑	↑	→	→	↑	→	↓	↓	↓
Switzerland		↑		→	↑	→		↑		↓	→	↓
United Kingdom	↑	→	→	↓	↑	→	↓	→	→	↓	↓	↓

Notes: The indication of a change direction is made based on the general pattern of the indicators' changes during the period after 2009. GBAORD was calculated as euro/inhabitant. The BERD and GBAORD indicators are expressed in euros per inhabitant. Venture capital funding in millions of euros. R&D employment in number of FTEs. The 'Ease of access to loans' is a weighted index.

2.3. Summary of findings

The analysis of the RDI and economic performance of the EU Member States in the time before and after the 2008 crisis has shown that different Member States exhibit different performance patterns and that several specific groups of countries can be distinguished. Finding the common patterns in such groups is not easy but also not impossible.

One can observe that the countries that appeared not to be affected by the crisis judged by their economic performance indicators also show positive post-crisis dynamics in their R&D inputs (such as Germany). At the same time, their R&D outputs and commercialisation enablers (such as venture capital or ease of access to loans) did suffer from the crisis, which can be taken as an indication that the tendencies influencing innovation activities cannot bounded by the national borders (in case of Germany) or relation to the EU (in the cases of Norway and Switzerland).

We also observe that the countries, which appear to have been affected by the 2001 recession (Austria, Belgium, France, Ireland, Italy and the Netherlands) appear to be the ones that managed to keep their private sector R&D relatively stable (although in most cases the previous growth in BERD has stopped). This was different for the government R&D expenditures, which did show a general declining pattern in Ireland, Italy, the Netherlands, and Portugal. Thus, there must be additional factors in these countries' industrial structure and/or policy mixes that can serve as explanation.

The cases of Greece and Spain, apart from their reputation of being the hardest hit by the crisis, are also interesting as examples where the predominantly positive pre-crisis dynamics in R&D inputs and outputs has changed into the overall decline in the post-crisis period.

Looking at the common patterns that can be detected in different European regions, we note several observations. The Nordic Countries appear to be mildly affected by the crisis when observing their general economic dynamics and not as much in terms of the knowledge intensive activities. They also show a less negative pattern in their RDI performance.

Eastern European countries have exhibited strong declines in general economic activity and to a lesser extent in knowledge intensive activities (mostly due to their small importance for these economies). In general the RDI performance indicators in this region did not show strong declines.

The countries of Southern Europe experienced the negative effects of the 2008 crisis in virtually all aspects of their activities: both in term of economic and RDI performance.

Finally, the Old Member States show mixed results, with the countries being affected to a different degree, although one can speak that their economic performance in knowledge intensive sectors has been rather resilient. The RDI performance changes in those countries exhibits different patterns with some performing stronger than others.

3. Research and innovation policies in the aftermath of the crisis

The aftermath of the 2008 global financial and economic and public sovereign debt crisis shook not only the evolutionary path of research and innovation activities but also of policies in Europe. The crisis caused difficulties to maintain research and innovation financing in several countries in times of increasingly tightening public budgets. As a consequence, some of the structural problems in the economy have become more apparent and urgent to address, such as the need to further shift to higher value added activities, rebalance the economy between manufacturing and services, better exploit the transformative power of services or changing the current situation of slow uptake of research results. European regions had to also face the relocation of some of their multi-national companies. This in turn also influenced decision-making in research and innovation policy.

Before turning to analysing the concrete research and innovation policies, let's first compare the national innovation policy challenges through a text analysis as identified and cited in 2006 and in 2012 in the Erawatch and INNO Policy TrendChart country reports. Table 3 summarises the top six challenges that have been mentioned in 2006 and respectively in 2012 by most of the countries (for the complete list please see the Methodological Annex).

The result shows that the types of challenges have somewhat changed. Funding and targeting of policies are two new challenges among the top 6 in 2012, where likely the prioritisation is linked to the smart specialisation[2] agendas as well. Science and industry linkages (as the most common in 2012) and supply of human resources are among the top 6 in both years, as entrepreneurship that can be linked to the creation of innovative enterprises. It is also interesting that institutional challenges such as the fragmentation of the public R&I administration or policy coordination have become one of the top issue that research and innovation policies are supposed to address in the upcoming period. These challenges are not all the direct consequences of the public debt or economic crisis (although the challenge of funding certainly is), but they are related as the macro-economic conditions and weakening of the business environment has made these issues more pertinent.

Table 4: Top challenges of national research and innovation policies in the EU

	Top Challenges 2006	**Top Challenges 2012**
1	Creating more innovative enterprises	Science-industry linkages
2	Supply of human resources	Supply of human resources
3	Science and industry cooperation	Institutional challenges
4	Innovation culture	Entrepreneurship and growth
5	Raising investments in R&D	Funding
6	Cooperation in the innovation system	Prioritisation and targeting of policies

[2] http://s3platform.jrc.ec.europa.eu/home

Figure 1 Key words of RDI challenges in EU Member States in 2006 and 2012

Notes: using wordle: http://www.wordle.net/create. Based on the list of innovation policy challenges cited in the EU27 country reports of INNO Policy TrendChart of 2006 and ERAWATCH in 2012. http://erawatch.jrc.ec.europa.eu/.

Following the issues identified above, this chapter is structured as follows: the first section will discuss the impact of the crisis on public research and innovation budgets, the second the impact on skilled human resources, the third the impact on policy governance and the fourth the changes in the policy mix (such as science-industry linkages, support to entrepreneurship and growth or indirect policy measures).

3.1. Pressure on public research and innovation budgets

As a result of the crisis, the most relevant challenge in many of the EU Member States has been the **stability of funding research and innovation policies**.

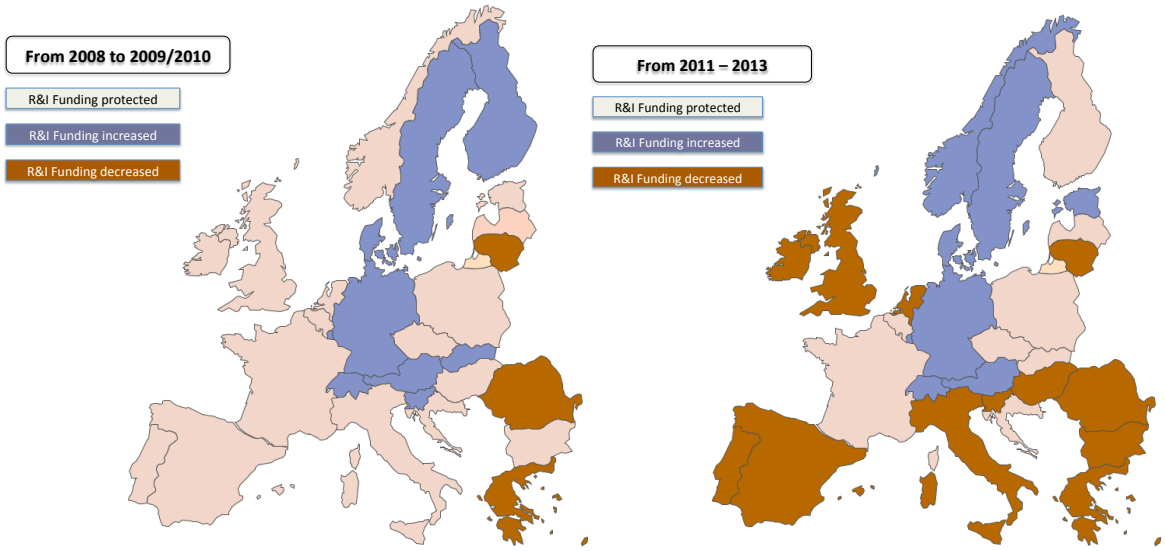
It was a positive revelation that many of the countries regarded research and innovation as a way out of the crisis and efforts have been made in many countries to 'protect' research and innovation budgets from general expenditure cuts. In countries such as Austria, Denmark, Estonia, Finland, France, Germany, Ireland, Lithuania (2010 onwards), Spain, Sweden and UK, innovation policy initiatives have been strengthened. In Ireland however there have been budget cuts in the field of research funding to higher education, the funding for industry-academia collaboration and applied research initiatives have been protected. Amid in the crisis, it declared its positioning as an international innovation knowledge hub. In Spain for instance the total GBAORD even slightly increased in 2009 while it began to decrease from 2010-2011 onwards.

On the other hand, some other countries, such as Bulgaria, Croatia, Hungary, Latvia, Romania, Slovakia or Slovenia, turned away from innovation policy and focused on macro-economic actions and crisis management. For instance, Hungary was busy trying to mitigate the results of the economic crisis and in 2010 it suspended several innovation measures and blocked 36,6% of the annual budget of the research and technological innovation fund (Havas, 2011). In some countries where Structural Funds were the main source of financing for R&D and innovation policy budgets, there was less change in the overall funding levels. In Slovakia and Slovenia in 2009-2010, for example, there were no cuts in the financial resources for R&D due to on-going Structural Funds measures, even if innovation policy was removed from the policy priority list. It should be noted that in most of the countries the budget cuts affected much more the direct public R&D expenditures such as the block funding for public research organisations and universities than competitive research and innovation programmes as reported by country reviews.

Although there was a countercyclical trend in 2008-2010 in terms of research and innovation public funding, this changed in the most recent period 2010-2013. Despite of the political commitments announced in Europe, the foreseen budget for R&D and innovation declined as a result of the serious financial problems in several Member States.

Figure 2 shows the trend in public R&I budgets in two periods since the start of the crisis: one is just right after in the period 2008-2010 and the second from 2011–present. The trend has been calculated by comparing the evolution in figures of GBAORD, the TrendChart inventory and based on qualitative country assessments, as the most recent figures are not available yet.

Figure 2: Trends in national public funding to research and innovation 2008-2009/2010 and 2011-2013



Note: The calculations are based on the analysis of GBAORD and TrendChart inventory funding figures.

Cyprus: 2008-2009 R&I budget protected; Cyprus: 2011-2013 – R&I budget increased; Malta: 2008-2009R&I budget increased; Malta: 2011-2013 – R&I budget increased

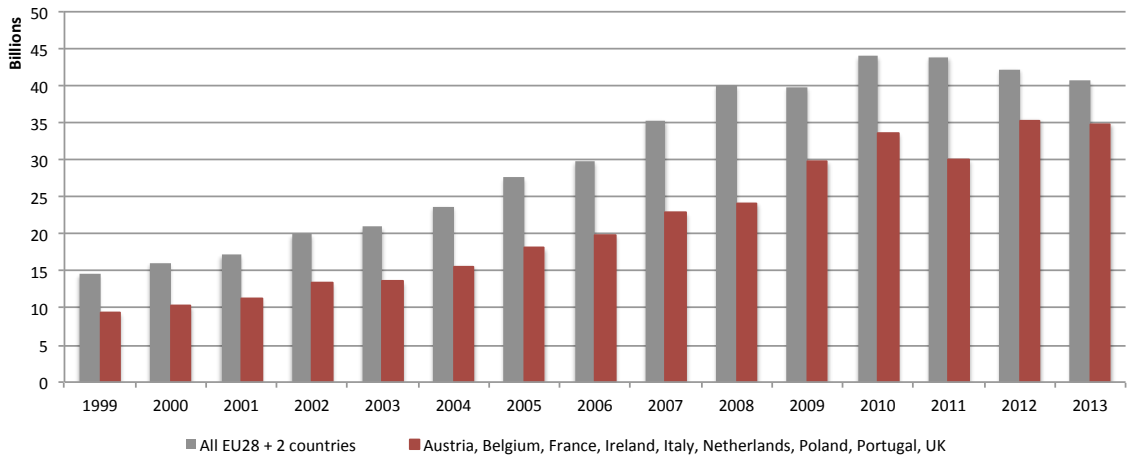
Comparing the trends in public research and innovation funding (based both on GBAORD and TrendChart inventory funding figures) the negative evolution is striking. Although research and innovation policies have been indeed protected immediately after 2008 until 2010, maintaining funding levels have become difficult more recently. In the period 2008-2009/2010, only **Greece, Romania and Latvia** that showed more than 10% decrease in their R&I budgets but this changed when looking at the 2011-2012/2013 period when **Bulgaria, Hungary, Ireland, Italy, Latvia, the Netherlands Portugal, Slovenia, Spain and the UK** turned into a negative trend. Slovenia, although cited as a positive example, has been also affected recently by the financial crisis and expects more pressure on their research and innovation policies as a consequence. *The fall in GBAORD figures in the case of Greece, Latvia, Romania and Spain are especially severe.*

The decreasing trends that can be observed in GBAORD figures are in certain cases the result of conscious consolidation and effectiveness measures or reallocations. For instance, science-base funding has been ring-fenced in the UK, which means stability for the research and innovation system. On the other hand the overall funding is expected to decrease. Even if efforts were made to stabilise the budgets despite the public austerity measures and the science budget was preserved, university budgets were cut by 40% in 2010 (Cunningham et al, 2011). The Dutch government made a shift in the use of their public R&I resources as a response to the crisis and as a result grants for businesses have been reduced and loan-based instruments have been increased (Mostert et al, 2012). In parallel to issues with funding, the crisis also depleted the capacity of enterprises to apply for new innovation projects although not to the same extent across Member States and posed problems to co-finance

innovative initiatives, and in many cases this led to a smaller number of operations funded.

Such trends in research and innovation public funding have not been observed in previous crisis periods. The dot-com bubble happened in 2000 did not result in a drop in research and innovation funding. The analysis of TrendChart funding patterns in Figure 3 shows a steadily increasing trend between 2000 and 2010 for the EU28+Norway and Switzerland. Figure 3 also demonstrates that the research and innovation public funding was not affected by the dot-com bubble in countries either where the analysis of Chapter 2 found that it had an impact on the economic or RDI performance indicators such as Austria, Belgium, Ireland, France, Italy, Poland, Portugal and the UK.

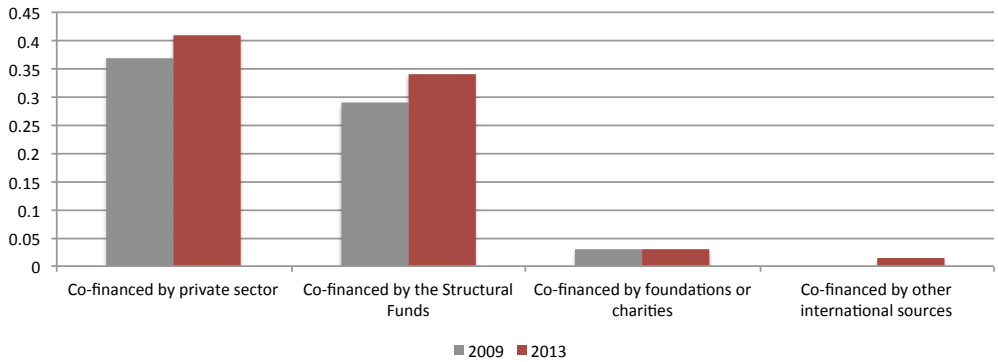
Figure 3 Trends in public R&I funding (in b euro) between 1999 and 2013



Shift towards other sources of co-financing

One consequence of the changes in national public research and innovation funding was that the importance of other sources has increased. The pressure on public funding led to seeking more for private-public partnerships in implementing research and innovation programmes, moreover the emphasis shifted towards the Structural Funds or other EU and international funding as more stable sources of financing (see Figure 4).

Figure 4: Sources of co-financing of support measures in EU27 in 2009 and in 2013 (y=in % of total budget)



Source: TrendChart database of support measures analysis of Technopolis Group. N= 959 (TrendChart, 2009) and N=792 (data downloaded on 8 November 2013).

While the above graph gives us an overall view, there are countries that exhibit different trends when viewed on their own. For example, in Austria the funding of research and innovation shows a minor shift from private to public R&D sources that demonstrated a counter-cyclical R&D expenditure policy in Austria (Schuch, 2012).

Shift towards competitive funding

Overall (although not across all countries) the importance of project-based (competitive) research and innovation funding relative to institutional funding[3] have increased in the crisis period in the EU (i.e. the budget for the functioning of public organisations, mostly comprised of salary and administrative costs). This has been, however, a longer trend going on since the early 2000s.

Table 5: Share of institutional vs project-based funding (within total R&I funding)

Country	Institutional funding (2011)	Project-based funding/competitive
Austria	67%* - increasing	33%
Belgium	26.2%***	73.8%
Bulgaria	22%* - decreasing	78%
Croatia	73%* - stable	27%
Cyprus	Na	Na
Czech Republic	52%*	48% - increasing
Denmark	96.6%***	3.4%
Estonia	31%* - stable	69%
Finland	Increasing**	Na
France	Na	Increasing**
Germany	40.6*	51.4 – increasing
Greece	Decreasing*	
Hungary	61%* - stable	39%
Ireland	40.1***	59.9
Italy	Decreasing	
Latvia	17%* - decreasing	83%
Lithuania	50%* - decreasing	50%
Luxemburg	Na	Na
Malta	71%*	29% - increasing
Netherlands	78%***	22%
Norway	Na	Na
Poland	33%*	67% - increasing
Portugal	Na	Na
Romania	33%* decreasing	66%
Slovakia	60%**	40%
Slovenia	Na	Na
Spain	40%**	60%
Sweden	Na	Na
Switzerland	Na	Na
UK	Decreasing**	More emphasis

Notes: * estimation referenced in the EW country reports ** own estimation based on TrendChart and GBAORD data ***OECD STI statistics 2010

In several countries such as the Czech Republic, Hungary, Latvia, Poland or Slovenia R&D funding has been traditionally dominated by institutional support. Recently there is, however, an increasing trend towards channelling funding through competitive programmes also given the fact that these countries are Structural Funds recipients. In the Czech Republic for instance, the share of institutional funds in GBAORD decreased from 56% in 2009 to 50% in 2013. The shifts towards competitive funding

[3] "Institutional funding is defined as the general funding of institutions with no direct selection of R&D project or programmes. Project funding is defined as funding attributed on the basis of a project submission by a group or individuals for an R&D activity that is limited in scope, budget and time." (OECD, 2011)

are also a result of budget cuts of R&D institutions – for example in Bulgaria and Romania, which increases the importance of other competitive funding such as the programmes managed through the Structural Funds. In Spain competitive funding has increased due to changes in the policy mix laying more attention to public-private R&D collaboration and research excellence. Similarly, we see an increased importance of project-based funding in France, Germany and the UK.

Nevertheless the trend is not applicable to Austria, Finland, Netherlands and Slovakia where institutional funding has been high and stable compared to competitive funding – the latter even increasing recently.

In principle more competitive funding could be regarded as a positive development, but on the other hand, too much of a drop in institutional funding can lead to unwanted imbalances. In case of Latvia the decrease of institutional vs project-based funding to 17%-83% brought instability to research organisations and universities and it is negatively affecting human resource development (Kristapsons, 2012).

3.2. Increasing challenge to preserve skilled human resources

The financial and economic crisis had a serious impact on another important pillar of research and innovation activities, notably on the availability of skilled human resources. Tight public budgets in certain countries has resulted in many researchers and innovative labour forces migrating to other regions due to low career prospects, the instability of the institutional system or salary cuts. The issue of safeguarding human resources has been raised across countries in the aftermath of the crisis. In some even specific policy measures have been launched to mitigate the effects, in others the most recent policy documents keep citing this problem. As the Global Competitiveness Report (2013) also found governments become more and more aware that educational systems should be better suited to the labour markets and structure of the economy and to nurture the innovative capacity and entrepreneurship needed in the future. We do not have exact figures about the level of net migration of qualified people as the latest data available comes from 2008. Nevertheless the analysis of trends in migration figures still can give an idea about the importance of this issue. Figure 5 summarises some of the shifts and lists the countries where there is an apparent negative tendency.

Figure 5: Migration trends in the period of the crisis

Country	Emigration 2008 rate: Tertiary educated	Emigration: 2008 nr of people	Emigration: 2011 nr of people	Net-migration in 2011	Migration trends: during the crisis (2008-2011)
Latvia	..	6.007	30.380	-23.127	negative and emigration increased substantially
Lithuania	..	17.015	53.863	-38.178	negative and emigration increased substantially
Poland	12,25	74.338	265.798	-108.739	negative and emigration increased substantially
Portugal	6,35	20.357	43.998	-24.331	negative and emigration increased substantially
Spain	2,39	288.432	409.034	-37.703	negative, emigration increased
Ireland	22,06	60.189	85.914	-33.613	negative, emigration increased
Greece	7,87	:	125.984	-15.161	negative, emigration increased
Czech Republic	..	51.478	55.910	-28.796	negative, emigration increased
Estonia	0,00	4.406	6.214	-2.505	negative, emigration increased
Bulgaria	..	2.112	Na		na

Hungary	8,44	9.591	15.100	12.918	positive, emigration increased
France	4,25	140.937	213.367	54.000	positive, emigration increased
Italy	3,75	80.947	82.461	303.332	positive, emigration increased
Malta	..	3.719	3.806	1.659	positive, emigration increased
Denmark	6,26	38.356	41.593	11.240	positive, emigration increased
Sweden	4,56	45.294	51.179	45.288	positive, emigration increased
Switzerland	9,83	86.130	96.494	52.305	positive, emigration increased
Romania	..	na	Na		Na
Austria	9,81	75.638	67.881	36.473	positive, emigration reduced
Belgium	5,81	100.275	67.475	77.223	positive, emigration reduced
Croatia	0,00	7.488	12.699		Na
Cyprus	24,84	10.500	4.895	18.142	positive, emigration reduced
Finland	6,14	13.657	12.660	16.821	positive, emigration reduced
Germany	7,09	737.889	249.045	240.377	positive, emigration reduced
Iceland	17,99	9.144	4.812	-739	negative, emigration reduced
Luxembourg	..	10.058	9.264	11.004	positive, emigration reduced
Netherlands	6,18	90.067	:		emigration reduced
Slovak Republic	..	4.857	1.863	2.966	positive, emigration reduced
Slovenia	0,00	12.109	12.024	2.059	positive, emigration reduced
United Kingdom	10,30	427.207	350.703	215.341	positive, emigration reduced

Source: OECD statistical tables and Eurostat, 2012

When complementing this picture with what can be learnt from national level surveys and studies on highly skilled migrants, the trend seems to be negative especially in Greece, Ireland, Latvia, Lithuania, Poland, Portugal and Spain. This finding is also supported by a recent OECD economic survey (2012) that found that in Ireland, Italy, Poland and Portugal have experienced a large share of skilled people emigrating from these countries. Interestingly the report also states that the outflows of highly skilled in the UK have been not balanced by the inflows either. The outflow of the highly skilled is, however, a complex matter. Their migration can stimulate the international diffusion of knowledge; some migrants return to their countries or keep linkages that foster innovative interactions, and this should be taken into account if further analysing this matter.

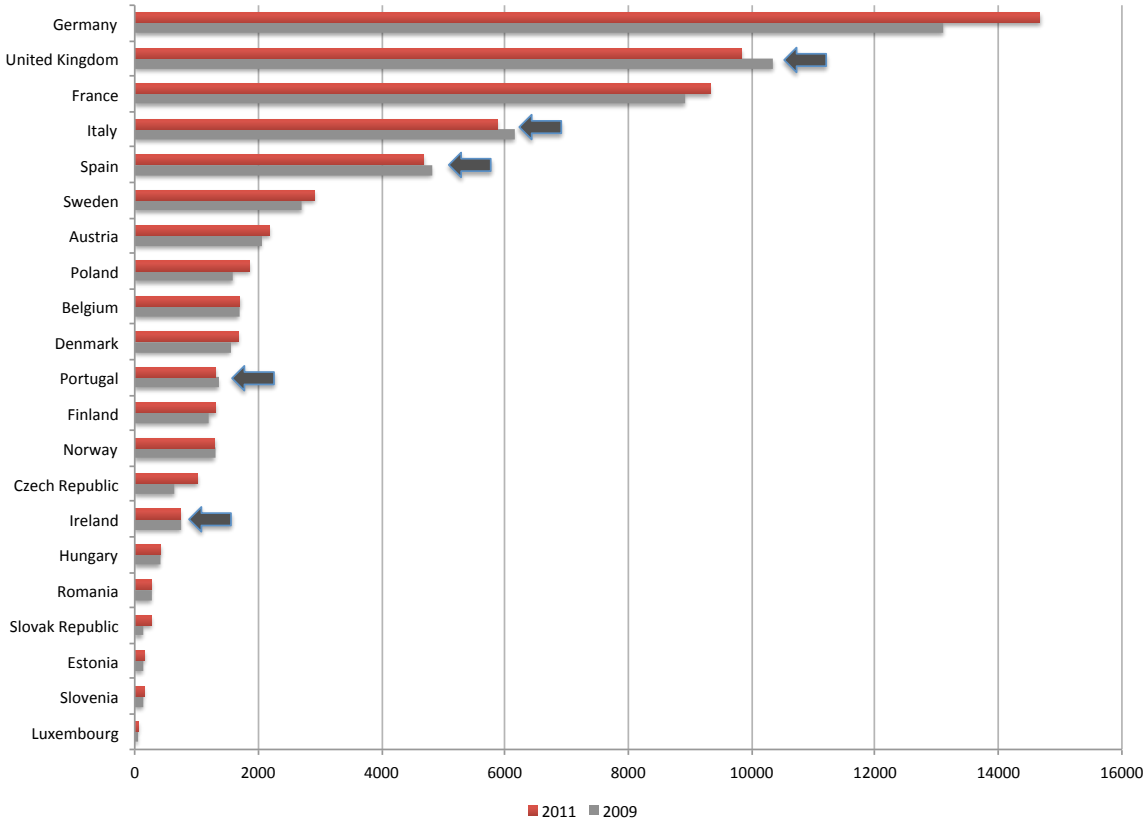
Comparing the above migration patterns with public spending on human resources points to some relevant gaps both in terms of general human resource development and with regard to higher education expenditure on research.

The overall situation of public funding on general human resource development has been found positive by a recent survey of the European University Association in Belgium (Flanders and Wallonia) and Finland showing stability. Austria, Denmark, France, Germany, Norway, Poland, Slovakia, Sweden and Switzerland also show an increasing trend (EUA, 2012). In all of these countries R&I public spending increased or remained rather stable.

Countries where a negative net migration occurred and where brain drain has been reported are also among those that decreased public spending on general human resource development. Greece, Ireland, Latvia, Lithuania, Poland, Portugal and Spain saw an overall decrease in public funding that amounted to more than 10% between 2008 and 2012 (EUA, 2012) together with further countries such as the Czech Republic, Italy, Hungary and the Netherlands.

This trend is further coupled with **a decrease in higher education expenditure on R&D (HERD) in countries such as in Ireland, Italy, Portugal, Romania, Spain and UK** (see Figure 6) that is alarming as it can further aggravate the situation of a stable human resources basis. These countries although showed a linearly increasing trend in HERD between 1990 and 2008, this increase reversed in 2009.

Figure 6 Trends in higher education expenditure on R&D (HERD) from 2009 to 2011



Source: OECD statistics, science and technology indicators, HERD in million dollars in constant prices and purchasing power parity

The issue of skilled human resources as presented above complements the findings of the 2013 Innovation Union Competitiveness Report (2013), which found that Europe faces both a challenge of investing in people and also a structural deficit in the mobility of scientists.

3.3. Consolidation and streamlining

In light of tightening public budgets and pressure on the national innovation systems, the crisis made policy-makers reflect on their range of policy instruments and delivery mechanisms. The analysis of research and innovation policies and policy measures in the aftermath of the crisis indeed shows a consolidation and reorganisation of implementation structures in many of the countries under scrutiny. Although innovation governance is path-dependent and it is shaped not only by the reaction to crisis events but by on-going changes, political cycles, inertia and policy learning, it is relevant to explore how these processes changed and are developing in the past few years.

The review of the TrendChart inventory of research and innovation policy measures demonstrate that there were around 167 fewer innovation policy measures across all EU countries in 2013 compared to 2009[4]. A majority of the discontinued measures were small-scale innovation support or pilot initiatives. Some of these were actually continued but as part of larger programmes. The number of collaborative R&D programmes also decreased in the total number of policy measures in the EU28+2. One of the reasons behind the consolidation was the endeavour to make the policy mix more transparent and accessible for the targeted beneficiaries.

To bring some concrete country examples: the user-driven innovation programme became part of the Business Innovation Fund in Denmark. The Danish policy support system has been streamlined to improve effectiveness by focusing on a reduced number of measures with larger budgets (Klitkou, 2012). In Austria there was a shift towards a reduced number of larger programmes, both in terms of budgetary volumes and the activities supported. The UK repackaged some of their policy initiatives into only a few instruments with sub-measures.

This consolidation, however, has not been a trend in all countries. For instance in Italy the crisis resulted in the adding of new or temporary measures to the existing policy mix that further complicated the scene of policy instruments (Poti et al, 2011).

Besides consolidation of policy measures, a streamlining and adaptation occurred in implementation structures as well. Nevertheless this did not mean substantial changes in the governance and main bodies that are usually well established especially in the innovation leading countries.

Box 1 Examples of consolidation of policy implementation structures

In the **Czech Republic**, following the research and innovation system reform in 2011 R&D support was simplified and concentrated into 12 funding organisations compared to the previous 22. Another streamlining is the strengthening of 'agencies', meaning that the Technology Agency, the Science Foundation and the Council for RDI got more responsibilities compared to the ministries.

In **Estonia** the Estonian Research Council was established in 2012 and now gathers most of the R&D funding instruments under its responsibility.

In **Hungary** a series of reorganisations of the research and innovation governance have been executed since 2009 (although frequent changes were characteristic in the prior period as well).

In **Ireland,** Forfas – a policy and advisory board for enterprise and innovation – is being merged into the Ministry of Jobs, Enterprise and Innovation to be completed by 2014. This is the result of a desire to better integrate innovation policy into the government's focus on job creation and competitiveness. Another change in the governance parallel to the endeavour to strengthen industry-science linkages is extension of the Science Foundation to be responsible for applied research programmes besides basic research as well.

In **Italy** the Monti government streamlined the research funds in 2011 in the framework of its actions of financial stabilisation.

Portugal has integrated the Innovation Agency into IAPMEI, which has been renamed IAPMEI Agency for Competitiveness and Innovation. On the other hand, it is unclear if this new agency will be able to carry out its wider range of tasks in an efficient way.

In **Sweden**, after implementing the R&I bill[5] in 2009, the 20 Strategic Research Areas have been reinforced significantly and much of the funding is distributed now in a more concentrated way to strong centres of excellence or research consortia.

Related to the mission of improving innovation policy governance, at least in terms of the territorial dimension, a recentralisation process was apparent in Hungary, the

[4] TrendChart inventory: 2009 N=959 and in 2013 N=792

[5] 'A Boost to Research and Innovation', Regeringens proposition (Government bill) 2008/09:50

Netherlands and the UK, which seized some of their regional innovation support schemes.

While there is certainly a need for rethinking innovation policy governance and for adapting it to the broadening and cross-sectoral view on innovation, the consolidation and simplification process might also jeopardise the efforts undertaken over the recent decade to develop research and innovation systems. For instance in Spain the pressure on public budgets resulted in reducing the number of public research centres and this might be threatening the stability of the research and innovation system. Similarly in Greece some of the existing structures have been destabilised through reorganisations, which did not increase efficiency but rather added new problems to existing ones.

Another important problem affecting national innovation policies within the EU is still fragmentation, duplication and overlapping. The protectionist policy approaches adopted by some of the countries in the aftermath of the crisis have further expanded this.

The challenge remains to keep a solid balance between renewing and improving innovation governance and guaranteeing the sustainability of past developments.

3.4. Quest for an innovation-based growth but no substantial change in the policy mixes

Besides being occupied with reinstalling macro-economic stability and rebalancing public budgets, unlocking business growth has become the focus of national policy debates across the EU. The crisis gave an impetus for EU Member States to strengthen their support to business innovation and react to the challenges of structural change. The challenge to enhance growth has been coupled by structural weaknesses in the innovation system. As a concrete example, in the last decade, the Flemish (Belgium) economic advantage has come under strong pressure and its previous growth model has been exhausted (Flanders Whitebook, 2013). There has been too little investment made in new growth markets, in service innovations and product innovations and much have to be done to improve again productivity. In the UK, there has been a growing concern that too often small innovative companies are bought up by overseas large firms and they cannot develop into the innovation champions of Europe (Cunningham, 2011).

The crisis did not, however, change substantially the national research and innovation policy mixes, although it amplified the attention in areas such as:

- Turning towards loans, guarantees and state-backed venture capital as alternative finance;
- More extended use of R&D tax incentives;
- More pressure on commercialising research results;
- Targeting/prioritising research and innovation programmes.

Despite several hot topics that have become popular in the aftermath of the crisis such as support to 'high growth enterprises' or demand-side innovation policies, the research and innovation policy mixes show more rigidity to changes than would be expected.

The review of research and innovation policy measures shows that indirect policies have become much more popular and **loans, guarantees, venture capital and R&D tax incentives** have been particularly used as a response to the crisis in its aftermath (more detail in Chapter 4). Some Member States turned towards new financing models. Nevertheless we should not let this new popularity mislead us as grants

remained the most applied mode of funding across the EU also shown by a previous analysis on research and innovation funding patterns (see also Mannik, Eljas-Taal, Rozeik, 2012).

The crisis also amplified the attention of policy-makers to some of the innovation policy hypes such as **'new technology based firms and young innovative companies'**. Venture capital support has been initiated to offer stronger incentives for private investors. Although young innovative companies have become a hot topic in many EU countries, specific measures have been less common. Young innovative company schemes have been introduced in Belgium in 2011, in Finland in 2008, and in France in 2004; however the construction of these schemes are different ranging from tax incentives (French ' young innovative company' status) to grants (Belgium) and to venture capital funding. The review of policy measures did not identify a trend in focusing more the research and innovation funding specifically to 'high growth enterprises' as such. This might be also related to the difficulty in defining this group.

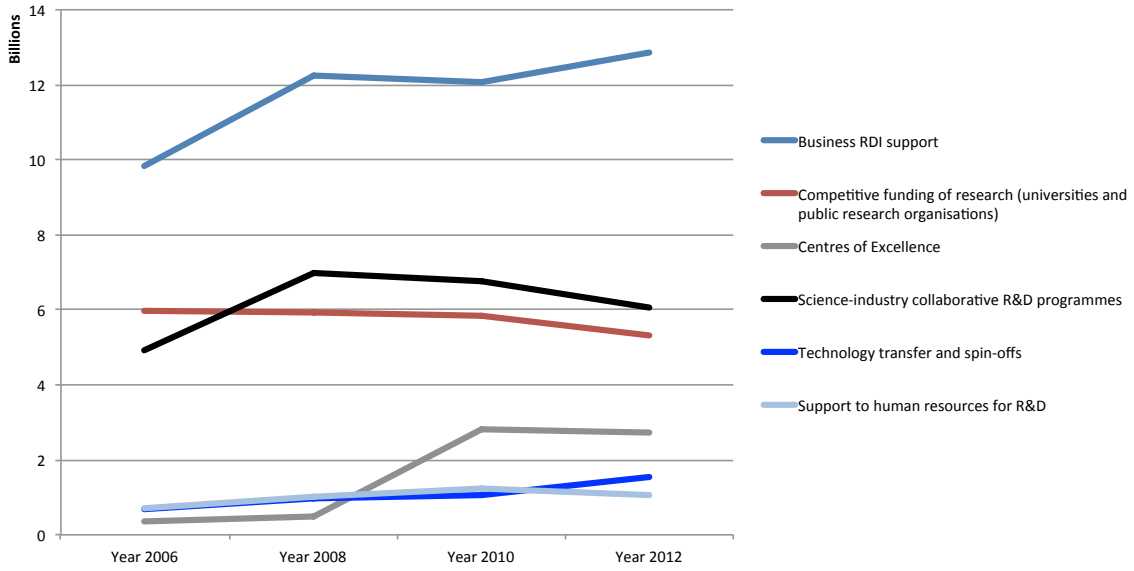
Another popular policy subject unfolding in the crisis aftermath has been **demand-side policies**. Several countries launched new measures (or pilot measures) especially in the areas of public procurement and pre-commercial public procurement (eg. Austria, Finland, Ireland, Italy, Poland, Spain and Sweden). Nevertheless these initiatives still remained in an initial stage and the lessons learnt varies. In addition they are not specifically related to the crisis but are the results of policy discussions especially going on since the Aho Report[6] in 2006.

Publicly funded research has had to face more pressure since the worsened economic situation urged policy-makers to take actions to maximise the economic benefits and foster job maintenance and creation. To this end, new policy measures have been introduced to **strengthen the commercialisation of research results** or foster university-industry linkages. This was especially the case in France, Ireland, Italy, Portugal and UK, and appeared in the Czech Republic, Poland and Sweden – although less related to the crisis and more of a result of an on-going debate.

The analysis of the TrendChart inventory of research and innovation policy measures underpins the above statements. Figure 7 shows that funding figures to business R&D and innovation and technology transfer are the ones that have increased as long as competitive funding for R&D decreased in overall in the EU28+2.

[6] http://ec.europa.eu/invest-in-research/action/2006_ahogroup_en.htm

Figure 7: Trends in the use of research and innovation policy instruments in total in b euro for EU28+2



Source: analysis of funding figures of the TrendChart inventory.

It is noteworthy that the analysis of funding figures shows a decline in allocations to science-industry collaboration programmes as well, although the country trend analysis claims the opposite and reflects an increased attention to academia-business linkages. One reason for the difference may be that collaborative research programmes are designed for a period of time and then are re-launched again. As we are approaching a new policy cycle in many of the countries, the new programmes might not be started yet as long as the old ones are running out what the above table might reflect. It is relevant to reinvestigate the future patterns at a later stage.

Another policy instrument deserving some attention is the support to centres of excellence that have increased substantially in terms of funding from 2008 to 2012. This reflects many of the large-scale research programmes launched in some of the New Member States, but also strengthening of measures for instance in France or Sweden.

While there has been certainly more attention devoted to prioritise research and innovation funding both in terms of identifying societal challenges to be targeted by research programmes or look for new technological and growth market areas that can be enhanced by innovation support measures, the analysis of the TrendChart inventory of research and innovation policy measures shows just a slight trend towards more targeted policies. Innovation policy funding remained mostly generic and in 2012, for example, around 60% of the support measure funding was not focused on any specific sector or theme (Mannick et al, 2012). As the national prioritisation exercises will only have a potential impact on the next generation of research and innovation policies in the upcoming period, this aspect would be worth of being revisited at a later point in time.

The concrete policy measures that have been introduced or strengthened in the crisis period will be analysed in detail in the following Chapter.

4. Measures and alternatives to foster innovation-based growth

This chapter analyses country policy responses to the crisis with the objective to preserve innovation activities and the lessons learned from policy measures that have been launched in the period 2008-2013 to stimulate an innovation-based growth. The time elapsed since then is too early to draw conclusions on the impact of these measures, but we can reflect on the results so far based on monitoring and mid-term evaluation reports. As the Annual TrendChart 2009 report identified there were two extremes of national policy approaches: a forward-looking, proactive approach and a short-term survival defensive approach (Tsipouri and Reid, 2009).

4.1. Revisiting research and innovation in 'crisis' packages

The impact of the crisis on research and innovation policies in the period right after the start of the crisis has been widely analysed. Nevertheless it is worth recalling the key points while summarising national policy reactions and reflecting on the first lessons learnt since the crisis began.

There was a fear that national policies will react by paying more attention to short-term crisis management rather than on investing in long-term research and innovation. To mitigate this both the OECD and the European Commission consistently emphasised the importance of including innovation in national 'crisis packages'. It was argued that innovation is a key instrument to boost productivity and sustainable growth (Tsipouri and Reid, 2009). The OECD warned the crisis should not damage long-term growth but instead accelerate structural shifts.

As a result many EU Member States integrated concrete research and innovation policy measures in their economic stimulus packages or introduced new temporary measures, even if these were limited in many of the cases. Table 6 provides a list including all countries (where relevant).

Common elements in the immediate actions taken included:

- Introducing measures to maintain human resources in R&D, fostering 'brain retain';
- Introducing or strengthening R&D tax incentives;
- Reallocation among measures (especially within the Structural Funds operational programmes - from measures with not enough applications to more popular or to economically more viable fields);
- Support to business innovation especially in the fields of ICT (broadband, infrastructure) and to green technologies.

Research and innovation policy measures are, however, long-term investments and it cannot be expected that their impact will be materialised in the short-term. This can be also felt in national reactions, as there were no major changes made in the ongoing policy measures and initiatives.

Table 6 R&I-related temporary measures and stimulus packages introduced to mitigate the results of the crisis

Country	*Policy measure*	*Date*	*Description*
Austria	Economic stimulus package	2009	The package put special focus on SME expanding credits for innovative SMEs, as well as public liabilities granted. A further component was the promotion of equity accumulation by the establishment of a fund for SMEs, which is governed by the AWS (Mittelstandfond) and also supported innovation projects.
Belgium	One-off Innovation Premium	2009, 2011	The objective of the measure is to stimulate a dynamic and culture of innovation in enterprises through a fiscal measure to encourage employers to awards 'premiums' (or bonuses) to employees who have contributed to the development of an innovation in the company. This one-off measure applied in 2006 has been reintroduced in 2009-2010 and 2011 as an extension of crisis measures.
Czech Republic	National Anti Crisis Plan	2009	The National Anti-Crisis Plan suggested increasing public investment in the field of R&I by 8% in the next three years; however, this did not happen to the full extent, although research and innovation funding remained stable.
Estonia	Reallocations of Structural Funds	2009	Reallocation happened from economically less important measures to more important ones.
Finland	Fiscal stimulus packages	2009	With a small amount of funding devoted to research, development and innovation including education, and (job-related) training; Tax incentives have been temporarily offered to support R&D and investments.
France	Recovery Plan	2008-2009	A number of priority high- or medium high-tech sectors were prioritised in the recovery plan: automotive, eco-technologies, nanotechnologies, ICT infrastructure.
Germany	Stimulus Package	2008-ongoing	Funding of technology and innovation for SMEs considerably increased: to counteract the effects of the global financial and economic crisis, EUR 900 million Euros were made available for Central Innovation Program SME (ZIM) as part of the second economic stimulus package in 2008 and 2009 in addition to the EUR 626 million originally planned. Especially, green technologies and investments in ICT were supported.
Hungary	Maintaining R&D employment	2009	The objective of the measure was to prevent brain drain and interim unemployment of skilled R&D personnel (including support for re-employment by innovative SMEs).
Italy	Brain-return	2009 – ongoing	Brain-return' measure: The 'anti-crisis decree' launched by the Italian government in November 2008 introduced fiscal incentives to attract Italian researchers living abroad back to Italy. The objective was to counteract the brain drain phenomenon. The measure consists on a tax incentive (10% tax applied to personal income) during the first five years of fiscal residence in Italy as of 10 January 2009.
Ireland	Technology Innovation Development Award	2009	It supports researchers to explore whether their ideas or products have commercial potential if further developed. Between 2009-2011 funding for enterprise science, technology and innovation support measures has increased slightly in Ireland.
Netherlands	Knowledge Workers Scheme	2009-2010	In order to counteract the impact of the financial and economic crisis on researchers, the Dutch government introduced this measure to help firms to make the knowledge and expertise of their researchers available to public knowledge institutes for a maximum period of 1.5 years. The researchers remained employed by the firm but worked on societal/economic themes.
Netherlands	High-tech Top Projects	2009-2010	Firms from the high tech sector, which has been particularly hit by the economic crisis, could receive a subsidy to enable them to continue their strategic R&D projects.
Poland	Reallocation of Structural Funds	2009	Reallocations from less popular measures to more popular ones.
Portugal	Creation of an autonomous fund to have the critical mass needed to influence Portuguese financial markets (FINOVA) FCT Researchers grants	2008/09-ongoing	FINOVA is aimed at developing SME financing mechanisms to strengthen the financial soundness, competitiveness and innovating potential of the Portuguese company fabric. The decision to create an autonomous fund, endowed with EUR 100 million, was justified by the objective to have the critical mass needed to influence Portuguese financial markets.
Slovenia	Promotion of R&D projects in SMEs	2009	The programme was part of the stimulus package to offset the effects of economic crisis on industrial sector R&D investment. Its goal was to stimulate investment of SMEs in research & development of new technologies, products and processes with the aim to increase the technological level of products/processes.
Spain	Plan E Law 14/2011, of 1 June, on science, technology and	2009 2011	'Plan E', launched by the government against this situation, EUR 490 million has been allocated for R&D. RDI investment against crisis was mainly focused on health and renewable energies sectors as well as expected to boost great installations and singular centres.

Country	Policy measure	Date	Description
	innovation		The aim of the Science, Technology and Innovation Law which replaced the so far prevailing Law of Scientific and Technological Research of 1986, was to establish a general framework within which to strengthen and coordinate scientific and technical research in order to contribute to sustainable development and social welfare by generating and sharing knowledge and innovation.
UK	Economic Challenge Investment Fund	2009-2010	The Economic Challenge Investment Fund provides support to vulnerable businesses to sail through the recent financial and economic crisis. The scheme has a short time frame in order to offer immediate support through improving business planning and strategy skills, implement innovation strategies and cost cutting processes. It aims at having a direct impact on the chances of keeping vulnerable companies in business by engaging with higher education institutions, by enabling innovative processes, knowledge transfer and business support.

Source: TrendChart Inventory

Support to public research institutions and educational programmes have priority in many countries. Measures such as supporting companies to use money from the European Social Fund for requalification training of their employees instead of sending them abroad have been particularly important and could safeguard capacities and help restructuring. Extended tax incentive measures have been also taken in several countries as a cheaper mechanism and incentive to hold onto business R&D expenditures. In several countries additional funding has been provided for SMEs and businesses with the aim to offsetting the negative impact of the crisis on innovation activities and supporting new innovative investments.

With the objective of spurring demand in the economy, actions were taken in the field of ICT infrastructure investments and support to the greening of the economy, two thematic areas receiving particular attention in the 'crisis' packages. The expectation was that ICT infrastructure and investments in a green economy will revive the business sector through new innovative services while also providing solutions to social challenges (OECD, 2009). ICT developments covered development of broadband infrastructure and support very high-speed communications in Austria, Finland, France, Germany, Portugal, Spain, UK. Countries strengthening green or environmental measures included Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Slovenia, Spain and UK. Austria's stimulus package focused on the greening of the economy and supported, for instance, the modernisation of the insulation of buildings and of power plants.

Some examples can be also identified where national policy makers introduced regulatory measures or new IPR rules to stimulate innovations. For example, a new law had been put in place in Sweden with regard to research by providing resources to the commercialisation of research results.

Although most of these measures have been welcome, there have been also critiques regarding the effectiveness of such short-term actions. The Austrian Institute of Economic Research (WIFO) claimed, for example, that the measures taken in Austria to support green growth were rather fragmented and insufficient in their overall impact. R&D tax incentives have been also criticised in that they did not reach real impact as some of the companies have been just relabeling actions and deducing the tax on their research activities that it had been anyway taken.

4.2. Looking for alternative financing mechanisms: loans, guarantees and support to venture capital

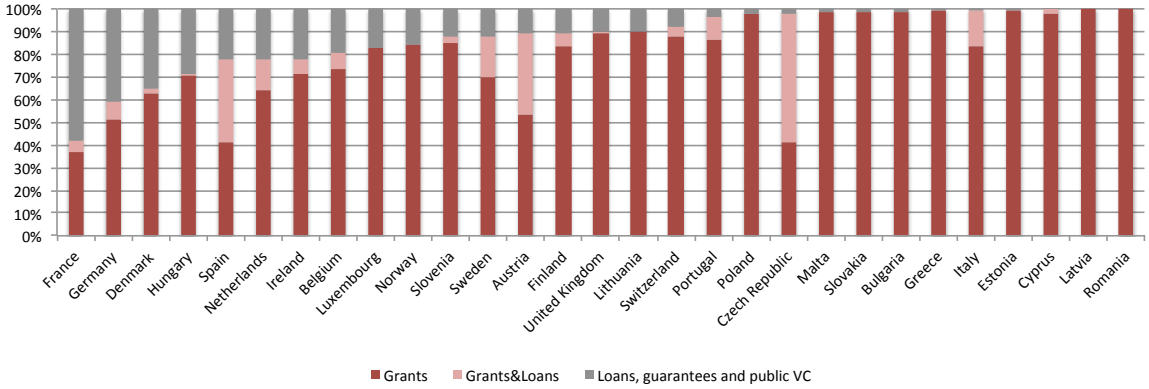
The crisis amplified existing worries about low business growth rates, weak entrepreneurship, underdeveloped venture capital and business angel markets. Lending practices have become more cautious towards risk taking and the shortage of funding to innovation projects (particularly in the early stages) has become scarce. This problem coupled with tightening public budgets, policy makers turned towards alternative financing mechanisms compared to grants such as loans, guarantee schemes and venture capital funds. Guarantees were seen as financing that can lower the risk of bank lending, could offset the market imperfections and have a leverage effect on lending to enterprises in times of the crisis. A renewed target of these policies has become the so-called *'young innovative companies'* that can reach fast growth and be the engine of the economy.

As the review of the research and innovation policy measures in the period of 2009-2013 shows, national governments provided increased support through loans, loan guarantees and venture capital measures. Private venture capital communities also urged for greater public sector involvement at a time when it was difficult to generate investment and raise capital. It must be noted that loans and guarantees have been welcome by firms who favoured this instrument for instance to private equity investments as referenced in several monitoring reports of policy measures.

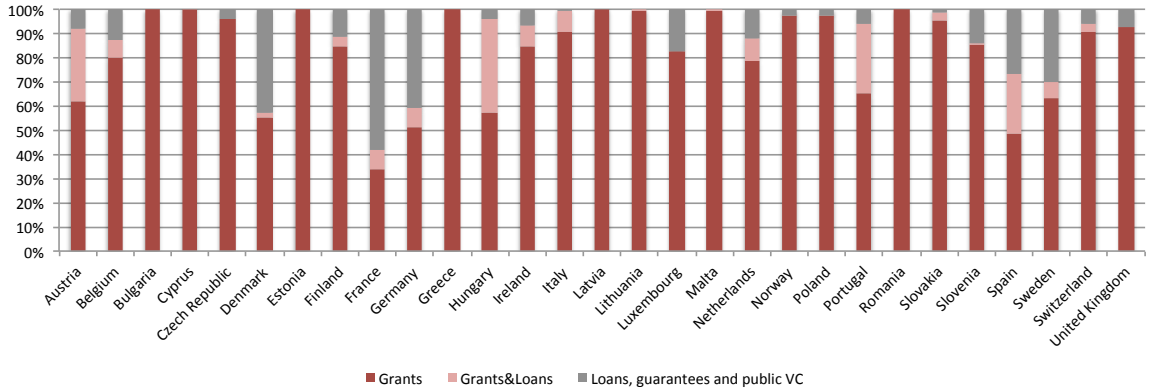
On the other hand, it should be emphasised that this trend did not change the overall national policy mixes and countries still rely much on grants rather than loans to support research and innovation as also addressed in the previous section. Figure 8 reflects that the composition of the programme-based research and innovation public funding in 2012 across Member States remained skewed towards the use of grants. Where loans, guarantees and venture capital schemes are a relatively more popular form of funding of innovation are for instance, Denmark, France, Germany, the Netherlands or Spain.

The trend greatly varies across many countries. While the analysis of funding figures shows some shifts (to different extents) towards these alternative funding modes in Austria, Belgium, Finland, France, Germany, Ireland, Lithuania, Malta, the Netherlands, Spain and the UK; however, there were no such trend observable in other countries such as in Bulgaria, Czech Republic, Hungary, Italy, Latvia, Romania or Slovakia. The figure has to be interpreted with caution as it contains more the allocations than the real expenditures. Moreover it is difficult to determine the amount of loans that were spent on real innovation projects and not just on 'usual' enterprise development.

Figure 8 Mode of public research and innovation funding in the EU countries in 2012



and in 2006



Notes: Grants & Loans refer to the funding of policy measures, which operate both through grants and loans and it was not possible to separate the value spent on each.

The calculations are based on the TrendChart inventory. The figures for loans and venture capital have been checked so that they reflect the amount of the state intervention and not the whole amount of fund including private capital and that they include the estimates spent on innovation projects and not in general firm growth. Nevertheless the percentages have to be interpreted with caution, as they are estimates.

Financial instruments to foster business innovation may take different forms such as revolving funds, investment in venture capital funds or loan-guarantee programmes. The funds can be completely state-backed or implemented in public-private partnership. There are funds that invest directly and that invest indirectly (fund of funds). It is also often the case that these measures do not have innovation as their first target but are more generic measures to ease access to capital to firms. Venture capital is often discussed as an alternative source of financing for companies, but it is more important in terms of its influence on business and innovation management.

Although we analyse these financial instruments together for the sake of this report, they fulfil very different roles in stimulating innovation at different stages of the innovation process. As long as venture capital funds are usually targeted at the start-up phase, subsidised loans and guarantees are provided at the growth stage of the firm evolution (see eg OECD, 2009).

We analyse below some of the recent and/or successful examples of loan-based or venture capital fund innovation policy measures that have been launched as a response to the crisis or had some links to stimulate business investment in research and innovation in the times of the crisis (see Box 2). As the summary box below also reflects there have been quite many new schemes launched across many countries during the 2008-2013 period.

Box 2 Loan, guarantee and venture capital support measures launched linked to the crisis or evaluated as important in the times of the crisis

Business Development Finance/Growth Funds, Denmark: is a public-private capital fund, which aims at creating new growth companies by providing venture capital and competence. Although operational since 1992, its 2010 evaluation concluded that the fund was critical at a time when the economic crisis negatively influenced the availability of venture capital - especially for companies in the early stages of development and it also states that the fund contributed to economic growth.

Strategic Investment Fund, France (2008): The main objectives of the fund were to support the development of SMEs, provide the backing to medium-sized enterprises and invest in high-growth sectors with innovation potential. The measure was a response of the government to the 2008 crisis.

HighTech Fund, Germany (2009): a public-private partnership to foster investments in high-tech firms. It is mostly financed by investments of the Ministry of Economics, however it acts similar to a private fund and it is completely focused on those early stages where market failures have been identified. The HighTech Fund has been evaluated as a successful instrument so far.

Vigo Accelerator Programme, Finland (2009): an acceleration programme that bridges the gap between early stage technology firms and international venture funding. The evaluation of the measure was positive. Some of the supported companies have been nominated among 20 most promising start-up companies in Finland.

FoF Growth Fund, Finland (2009): launched in 2009 to support SME growth. The assessment of the Finnish Industry Investment concluded that the end of 2012 the portfolio of companies employed some 50,000 people and their aggregated net turnover amounted to approx. EUR 8.5 billion. The number of Finnish Industry Investment's portfolio companies' employees grew in relative terms four times as much, and aggregate net turnover almost twice as much, as those of Finland's total stock of companies.

SME Loan Guarantee Scheme, Netherlands (2009): because of the financial and economic crisis this measure was expanded in 2011, which aims at providing SMEs a government guarantee for part of a bank loan.

AWS Mittelstandsfond, Austria (2009): launched in 2009 with the objective to strengthen the access to finance of medium-sized companies in the growth stage and it has become the largest state-backed Austrian fund offering 'silent' equity for firms. It has a term until end of 2025 and with a fund of EUR 80 million.

Innovation Fund, Ireland (2010): it provides seed and venture capital as part of the National Recovery Plan 2011-2014. With a budget of EUR 125 million Enterprise Ireland invests in international venture capital funds that establish a presence in Ireland.

Innovation Investment Fund, UK (2010): It was a policy response to encourage investment into new businesses during the financial crisis that had tremendously affected the private equity market. It is a Fund-of-Funds that has been supporting a small number of specialist technology venture capital funds to invest directly in high-tech SMEs, start-ups and spin-outs with high potential of growth and innovation. It has successfully addressed the gap in the supply of equity finance in the times of the crisis. Its positive feature was that it has been managed by private venture capital experts whose experience was instrumental in taking good decisions (BIS, 2012).

SME+ Innovation Fund, Netherlands (2012): it assists emerging technology and creative entrepreneurs by investors to convert their knowledge into suitable products or services. In 2012 the SEED Capital scheme was merged with the Innovation Credit scheme to form the SME+ Innovation Fund. The funding to the Innovation Fund was increased significantly, a budget of EUR 500m is available for the period 2012-2016. This new Innovation Fund is more open to applications from large companies instead of just SMEs.

Start-up Co-investment Fund, Spain (2012): This measures promotes economic growth, job creation and modernisation of businesses through investment in start-ups. Loans are granted to start-ups in cooperation with investors previously selected and accredited for this purpose.

Portugal Ventures, Portugal (2012): as a result of the merger of the three state-owned venture capital organisations: AICEP Capital Global, InovCapital, and Turismo Capital. Portugal Ventures focuses its investments in innovative, scientific and technology-based companies as well as in companies from the more traditional tourism and industrial Portuguese sectors, with significant competitive advantages and export oriented to global markets.

Creative Innovation Development, Lithuania (2012): new risk capital measure that aims at promoting cooperation with Lithuanian and foreign universities, research and development centres and other education institutions and support the commercialisation of high-tech ideas. Two risk capital funds have been set up in this framework: Seed Fund and Start-up Fund.

FOND-ICO Global fund, Spain (2013): Spanish state-backed bank (Instituto Credito Oficial=ICO) has launched a EUR 1.2bn venture capital fund of funds to provide an alternative source of financing to Spanish SMEs in 2013. It will help projects that combine innovation and

entrepreneurship. This is the first public fund of funds in Spain with such a volume of investment.

Growth Financing programme, Finland (2013): Finland will set up a long-term growth-financing programme to consolidate the capital investment market and support SME growth.

Slovenian Enterprise Fund, Slovenia: in Slovenia credits for R&D investment by business companies to be disbursed via the Slovene Export and Development Bank have been expanded. The amount is EUR 150 million available till end of 2013. It still offers credit guarantees, while other lines of credits or subsidies have ceased in 2012.

Source: Erawatch/TrendChart database and further desk research

Key characteristics of measures launched during the times of the crisis

Funds addressing specifically the crisis

The French Strategic Investment Fund (FSI), UK Innovation Investment Fund and the Irish Innovation Fund have been set up within the government's response to the crisis. In essence, they are strategic investments to have a leverage effect in new businesses during the unfavourable economic times.

The UK Innovation Investment Fund was launched in 2010. It has been supporting a small number of specialist technology venture capital funds to invest directly in high-tech SMEs, start-ups and spin-offs with high potential of growth and innovation. The priority sectors were the life sciences, low carbon technologies, ICT and advanced manufacturing. An early assessment of the measure was conducted by BIS in 2012. **The UK Innovation Investment Fund has been found to successfully address the gap in the supply of equity finance in the times of the crisis.** One of its positive features was that it has been managed by private venture capital experts whose experience was instrumental in taking good decisions (BIS, 2012).

FSI was launched in 2008 in order to help promising French enterprises to obtain funding and to secure their capital. The FSI is a limited company, which takes minority shares in French companies carrying out industrial projects that create economic benefits and competitiveness. It aimed at supporting innovative and industrial projects. The first investments in 2008 of this new fund have been allocated to the automotive sector (Valeo, Daher, for instance). In a context of scarcity of new investments in equity capital within innovative companies, the FSI has decided to reinforce its actions in favour of biotech companies in order to support this strategic economic sector.

In Ireland the new **Innovation Fund established in 2011 provides seed and venture capital as part of the National Recovery Plan 2011-2014.** Through this initiative, the Government made 125m euro available for Enterprise Ireland to invest in international venture capital funds that establish a presence in Ireland and that invest, at a minimum, an equivalent amount in Irish companies or companies with a significant presence in Ireland. The main objective of Innovation Fund Ireland is to increase the number and scale of innovation driven, and high-growth businesses in Ireland. The National Pensions Reserve Fund has been working closely with Enterprise Ireland and the Department of the Taoiseach to assist in setting up this Fund.

Public-private partnerships

During the crisis period several public-private innovation funds have been set up with the aim to foster business innovation and growth. Although these policy measures are not a response to the crisis but had some impact on mitigating the crisis effects as the most recent monitoring and evaluation reports show.

The Finnish Ministry of Employment and Economy launched the **Vigo Accelerator Programme** in 2009. Vigo aims at bridging the gap between early stage technology

firms and international venture funding. The Accelerators are co-entrepreneurs who invest in the companies they work with to guarantee common goals and committed development effort. The programme is an example of extensive public-private collaboration. The backbone of the programme is formed by the Vigo Accelerators, carefully selected independent companies run by internationally proven entrepreneurs and executives. These Accelerators help the best and the brightest start-ups to grow faster, smarter and safer into the global market. The Accelerators are not consultants but co-entrepreneurs who invest in the companies they work with to guarantee common goals and passionate development effort. The current Vigo Accelerators are for example in the area of clean-tech, food process, life-sciences ventures. As the most recent monitoring reports showed, Vigo has helped more than 50 companies to grow and some of the supported companies have been nominated among 20 most promising start-up companies in Finland.

The **German HighTech Fund (HighTech Gründerfonds)** is a public-private partnership to foster investments in high-tech firms. The scheme is implemented as a public-private partnership of BMWi, the KfW Bank group and six leading Germany companies such as BASF, Bosch, Deutsche Telekom, Daimler, Siemens und Zeiss. It is mostly financed by investments of the Ministry of Economics, however it acts similar to a private fund and it is completely focused on those early stages where market failures have been identified. The Fund started in 2005 with a volume of EUR 272m. Its second edition was introduced in October 2011 with an additional investment volume of EUR 291m. The fund targets new foundations that are less than one year old, with not more than 50 employees and with a clear high innovation potential (Walendowski, 2011). It finances especially spin-offs from universities, research institutions or large companies. The objective is to bridge the gap of finance for new enterprises with high technological and market risk. In addition, Germany is planning to introduce a new measure to support investment through venture capital. The grant will be available to private investors and business angels in particular who are willing to invest in young innovative companies and to offer those companies help and advice.

The HighTech Fund has been evaluated as a successful instrument so far, although the lengthy process and the subordinated loan aspects have been negative overall. It reached the ICT sector yet several of the other sectors are not yet sufficiently covered such as energy, nanotechnology or environment. **The evaluation of the Fund performed in 2010 concluded that both entrepreneurs and the venture capitalists welcomed the activities of the Fund**. Two factors have been identified that are responsible for its success: the independence of the Fund (so that it can act entrepreneurially) and the significant volume of the Fund.

In Denmark the **Business Development Finance/Growth Funds** is a public-private capital fund that aims at creating new growth companies by providing venture capital and competence. Since 1992 Vækstfonden has, in cooperation with private investors, co-financed growth in 4,100 Danish companies with a total commitment of approx. DKK 11.4 billion. It supports Danish companies by helping to finance R&D, internationalisation and skills development projects. With the launch of the new strategy the Growth Fund also aims to invest in venture companies and thus contribute to the development of venture capital industry in Denmark. The Danish government has also expanded the target group in 2011 in order to allow that firms with up to 250 employees can also access the measure. In 2011, the Fund was strengthened by the establishment of a subsidiary, which gives access to the financial resources of pension funds. A new loan scheme from the Danish Growth Fund was launched in 2012.

Its 2010 evaluation concluded that **the fund has contributed to economic growth which would not have been possible without this support** (Ernst & Young,

2010). It invested in companies that other actors did not wish to invest and created an economic activity that would not otherwise have taken place. This was critical at a time when the economic crisis reinforced the lack of venture capital. The measure was found efficient in terms of its cost-benefit ratio as it had low administrative costs per payment in the period 2001-2008.

France launched the Bank of Public Investments France (**BPI France)** in 2012, a public-private partnership support innovation and internationalisation of companies. Some of its major activities are innovation funding, guarantees on bank financing and venture capital. It plans to invest approximately EUR 12 billion by 2017 in 7 companies. The Fund is generic, meaning that a wide range of sectors can benefit from the Fund, although there have been strategic axes identified such as 'health and digital'. In addition, there are envelopes on the social economy and ecological transition.

Asymmetric funds

Finland's new stimulus package launched in 2013 relies on public-private partnerships with a minimum of 50 per cent of the required capital to be raised from private sources. They expect to create 6,000 new jobs within five years. The new **Finnish Growth Fund** is asymmetric, which is to say the public investor can cap its required rate of return to some pre-defined level, the excess of which would be distributed among the private investors in the Fund. This is expected to motivate more private investment in the Fund. The funding will be channelled through Tekes and Finnish Industry Investment Ltd. The Finnish Industry Investment Ltd will be capitalised by EUR 30 million per year for the financing of the programme. EUR 20 million from the existing resources of Tekes will also be allocated to capital investment. In addition, the direct investments of Finnvera will be capitalised by an annual EUR 5 million during the transition period lasting until 2017, after which time the state will no longer make new, direct investments in the companies. This programme represents one method of answering the dramatic structural changes in the ICT industry and other industries.

The forerunner of the growth programme was the FoF Growth Fund[7] established in 2009 together with Finnish pension funds, including Ilmarinen Mutual Pension Insurance Company, Local Government Pensions Institution, State Pension Fund, Eläke-Fennia Mutual Insurance Company, Tapiola Mutual Pension Insurance Company, OP Life Assurance Company Ltd, OP-Eläkekassa and Etera Mutual Pension Insurance Company.

In spring 2013 Finnish Industry Investment conducted an assessment of the economic impact of its investments during 2011-2012. At the end of 2012 Finnish Industry Investment's domestic portfolio companies employed some 50,000 people and their aggregated net turnover amounted to approximately EUR 8.5 billion. The number of Finnish Industry Investment's portfolio companies' employees grew in relative terms four times as much, and aggregate net turnover almost twice as much, as those of Finland's total stock of companies. In 2011 and 2012 seven times the amount of capital was channelled into Finnish Industry Investment's portfolio companies compared to its own investment in them. **The investments actively influenced the creation of new players in the venture capital market in Finland.**

Supporting start-ups

One of the new programmes of the Spanish ENISA - a public company attached to the Ministry of Industry, Energy and Tourism - is the **Spanish Start-up Co-Investment Fund,** which was launched in 2012. It promotes economic growth, job creation and modernisation of the business through investment in start-ups. This co-investment

[7] http://www.industryinvestment.com/investments/fund-investments/fof-growth

programme is not just a tool to develop the Spanish venture capital market, but also a programme designed to attract the interest of specialised investors to the high-potential entrepreneurship. Loans are granted to start-ups, in joint venture with its partners previously selected and accredited as investors for this purpose. ENISA in collaboration with IE Business School has developed selection criteria that investor partners must meet in order to join the programme. The co-investment fund is made up of equal contributions from ENISA, Spain's leading government agency for the development of innovation based and high growth potential companies, and an international group of specialised private sector investors.

In Lithuania INVEGA launched a new pilot called '**Creative Innovation Development'** in 2012 with the objective to select financial intermediaries who will promote the commercialisation of ideas generated in education institutions. This new risk capital measure aims at promoting cooperation with Lithuanian and foreign universities, research and development centres and other education institutions by providing financial means to implement the projects of new commercial high-tech ideas. Two risk capital funds have been set up: Seed Fund and Start-up Fund.

Global outreach

The **FOND-ICO Global fund** – which is the first such fund launched in Spain by the state-backed bank 'Credit Institution' (ICO) in 2013 – aims to stimulate the creation of new venture capital funds in the country. It is non-bank financing for projects that combines innovation and entrepreneurship. It is expected that it will assist in creating some 40 new venture capital funds that will raise up to EUR 3bn and invest in businesses at various stages in their development. This initiative is part of the measures contained in the 'Economic Stimulus and Enterprise Support Plan'.

Portugal Ventures, as a result of the merger of the three state-owned venture capital organisations: AICEP Capital Global, InovCapital, and Turismo Capital. Portugal Ventures claims to focus its investments in "innovative, scientific and technology based companies as well as in companies from the more traditional tourism and industrial Portuguese sectors, with significant competitive advantages and export oriented to global markets".

The **AWS Mittelstandfonds** (Fund for Medium-Sized Businesses) is the largest state-backed Austrian Fund offering 'silent' equity for medium-sized companies. It was founded in 2009 with a term until end of 2025 and with a fund of EUR 80 million. The financing of the international expansion stage is still a major challenge for Austrian small and medium-sized enterprises. The AWS Mittelstandsfond offers an attractive alternative to bank loans with its silent shareholder financing. The positive feature of Fund is seen in the ability to support company growth, while ensuring long-term positive effects on employment.

Lessons learned

Lessons learned from the venture capital or loan-based measures launched since 2009 varies across countries. Based on the review of policy measures, their monitoring and evaluation reports and related working papers we summarise below the issues that these schemes raise.

Loans cannot replace grants

While loans, guarantees and venture capital schemes sound as viable and cheaper alternatives to support innovation in the times of tight public budgets, one must be cautious. Grants, subsidised loans and venture capital measures are not interchangeable alternatives. They all play a role in different contexts and different development phases in the innovation cycle. Grants are usually more suitable in financing the idea development phase as long as loans and venture capital measures

are needed to foster the commercialisation of research results (Technopolis, MIOR, 2012). Subsidised loans are usually mechanisms for a longer term and with a higher administration cost.

Loans, guarantees and venture capital funds can work when there are already ideas to commercialise that might be there in countries closer to the technology frontier, but play a different role in countries with a less developed innovation culture. In these countries if the measures are not complemented by strong measures to support innovation culture and skills, shifting towards more loan-based instruments won't reach the intended impact.

As the country cases studies will also discuss in detail later on, *loan-based instruments are not a straightforward solution to finance innovation* in Greece, Spain or Portugal. In Greece there was an attempt to shift towards loans but it did not work due to the general conditions of the banking system. Similarly, in Portugal the operational difficulties hamper obtaining guarantees and limit businesses willing to invest in R&D and innovation in obtaining support.

As recently highlighted by several authors, the supply of new ideas relies more on the creativity, skills and networking capabilities of firms than access to financial capital (Tether and Stigliani, 2012; Ramlogan and Rigby, 2012). There is a risk that a business will in the end go abroad when it has reached a sufficient size to look for better entrepreneurial environments – and in that case the public investment is not realised within the country. Jobs will not stay automatically in Europe once an investor or venture exits. There is a need for investing in the whole innovation system in parallel to venture capital measures. Some authors warn that while R&D investments are not enough to stimulate economic growth on their own, the public intervention is essential in the seed phase of radical innovations more than venture capital (Bogliacino and Lucchese, 20110; Mazzucato, 2011; Perez, 2010).

We would argue that as long as the strengthening of alternative financial mechanisms will solve some of the important problems of commercialisation of research results, it cannot be regarded as an alternative to grants. A balanced development of the policy mix portfolio is necessary.

Supply of funds should be matched with sufficient number and quality of projects

As several reports highlight, it is not enough to have funding; there is a need for innovative ideas and quality projects. The challenge is not to only support the creation of new start-ups, but how to match this with adequate supply of innovative projects that offer high quality and to unlock a faster growth and raise the quality of the firms (Reid and Nightingale, 2011). To couple supply with demand might need that the start-up loan or venture capital measures are accompanied by measures to raise demand for innovations such as pre-commercial public procurement or innovation procurement schemes.

For example, the number of supported projects by the Portuguese Innovation Support System measure launched in 2007 was very low. The measure aimed at encouraging entrepreneurship, particularly in companies with knowledge and research and also addressed company creation in industries with strong demand. The measure had been evaluated in 2011 and found that the level of eligibility was lower than the average eligibility figure in the whole operational programme. Although the assessment concluded that companies welcomed the measure, it concluded it was insufficient to stimulate entrepreneurship. New initiatives were launched in 2012 to stimulate young entrepreneurship. It might result in 'forced' investments and low quality projects that will not result in the expected growth.

A key success factor is good governance and an organisational model so that demand finds supply. There also needs to be enough high-quality projects with skilled entrepreneurs who have the ability to develop new growth and jobs.

Another issue pointed out in evaluation reports in a number of countries such as Greece, Lithuania, Portugal, Slovakia and Romania is that not all projects supported are with high innovation content, thus the support measures do not contribute to the goal to raise the innovativeness of companies. The Portugal NEST measure (a new technology-based firm support system) effective from 2002-2006 has been even less successful than the Innovation Support System programme due to very limited uptake of funds by innovative enterprises.

In Slovakia, the case of the Fund of Funds launched since 1994 in different forms, one issue is that as long as the amount of available funding is relatively high, there has been a low number of real innovative projects supported. It is comprised of a start-up capital fund, regional start-up capital fund, INTEG fund and seed capital fund. For instance the risk capital fund INTEG that was established in 2004 supported so far no innovative projects and in general there is low innovation content in the projects. There is a need to maintain high selectivity and aiming at finding the most promising projects. In Romania there are similar experiences with projects financed through the National Credit Guarantee Fund for SME programme.

Competence and skills

Another critical issue is to develop the competences and skills of start-ups or gazelles besides financing. It is not only the funding that is important but also how to attract more experienced managers and serial entrepreneurs to collaborate and mentor the enterprises (UK, France, Finland).

For example, the UK GrowthAccelerator was launched in January 2012. It is delivered 'by the private sector for the private sector' and provides high growth potential to small businesses with the know-how and ability to achieve sustainable growth. It is a service led by some of the successful growth specialists who offer new connections, new routes to investment and the new ideas and strategy. Portugal launched the 'Entrepreneurship Passport' policy measure, a grant that is given to young graduates committed to develop entrepreneurial projects. The purpose is to support 'projects with high potential that are still in the idea phase'.

There is a risk that state-backed investment funds create an artificial environment and add capital to underperforming areas, which has to be mitigated. Lerner (2013) warns that for every public effort at spurring entrepreneurial activity, there are many failed efforts, wasting untold billions in taxpayer dollars. "Governments cannot dictate how venture markets evolve and that's why they must balance their positions as catalysts with an awareness of their limitations." Independence of the innovation funds has been found as important to have success. Involving private sector venture capital experts has been found as an important success factor.

Supporting the right target group

The measures usually address the 'valley of death' in the evolution of start-up companies, the stage when access to finance is most critical in the early stages (Sunley et al, 2005). But this valley has several gaps that have to be bridged, not just in the initial stages but also later on in the pre-IPO phase when firms want to transform their technical feasibility into commercial activities. Most of the schemes target start-ups or SMEs. Nevertheless a recent study found that middle-sized companies that are not any more SMEs but not yet large companies contribute more to GDP than firms in other sizes in Germany, France, Italy and the UK (Malshe, 2012).

They might represent a basis for future growth but often they are overlooked because they are just beyond the definition of an SME. Although this is more characteristic to larger economies, it can be beneficial to re-examine who are the potential growth champions.

Linking financial mechanisms to export promotion

It is critical to integrate an international dimension into the loan or venture capital-based support schemes, meaning that there is also support available for companies in their early growth stages to the international stage. As the domestic demand is low, enterprises are looking for markets and funding outside of the country, which is raising the importance of export support measures. These are key to develop innovative approaches enabling the companies to improve their performance in international markets. In particular, specific initiatives should be launched with a view to enable the most innovative companies to successfully introduce their new products and technologies in the most affluent and sophisticated markets.

4.3. R&D tax incentives during the crisis: a viable tool to support business R&D and innovation in the future?

R&D tax incentives are among the measures that have particularly **increased in popularity during the crisis**. In the EU a significant number of countries (see Box 3) explicitly referenced the introduction and/or enhancement of tax incentive measures (based on the review of Erawatch and TrendChart country reports and further desk research). In fact, during the 2009-2012 period, tax incentives represented a significant part of the overall public RDI funding. Some reasons possibly explaining this trend are the design features of such schemes i.e. implementation simplicity and flexibility, low administrative costs for all parties engaged, broad reach to all types of companies and R&D content.

Looking across the use of R&D tax incentives in the EU we find a number of countries that have several years of experience and strengthened this policy instrument as a response to the crisis (more than 15 years in Austria, Belgium, France the Netherlands, Spain and Portugal), countries which have launched such R&D tax incentive mechanisms during the period of the crisis (Greece and Romania) and countries which have only recently done so (Finland). There are also countries that limited the scope of their R&D tax incentives, such as Hungary, or most recently Portugal. The experience of Spain shows that while it kept on offering a generous R&D tax incentive system, the amount of claimed deductions decreased as a percentage of BERD. As long as it was around 5-6% of the BERD in the period 2002-2006, the deductions for 2008-2009 were 4-5% (Heijs, 2011).

Box 3 R&D Tax incentives - Recent Changes

Austria: Among the recent policy measures are the reform of the tax allowance system, which enables a higher public funding quota, while eligibility criteria and criteria enforcement have been tightened simultaneously. As of 1 January 2011, the R&D tax incentive called 'Research premium' has been increased from 8% to 10%, which is the percentage of the monetary efforts for R&D (including experimental R&D) of enterprises that can be received back as credit voucher from the tax office.

Belgium: The Belgian government put in place a series of economic stimuli measures to boost the Belgian economy in 2012, including incentives to reinforce R&D and innovation. As a result the partial salary withholding tax exemption for research was increased from 75% to 80%, bringing an additional reduction of the costs for employing researchers. Tax subsidies amounted to EUR 177.4m in 2007, which increased to EUR 460m in 2009.

Czech Republic: The government's innovation action plan for 2014-2020 foresees to further extend R&D tax credits which would become applicable to purchase external R&D services from

research organisations that in turn would promote more science and industry relations.

Finland: The government budget for 2013 has for the first time included two tax incentives aimed at growth seeking businesses.

France: The government has agreed to temporarily modify the statutes of the tax credit in order to provide temporary tax relief. Due to the financial and economic crisis, companies can obtain the immediate refund of their research tax credit of 2005, 2006, 2007 and 2008 not yet used or mobilised. The research tax credit has been extended in 2013 by granting SMEs the possibility to include innovation costs (such as trademark and design registration). On the other hand there have been also restrictions introduced in 2012: lower tax breaks for first time applicants and a tightening of conditions regarding sub-contract tax breaks and lower tax breaks after 5 years for young innovative enterprises.

Ireland: improvements have been made to the R&D tax credit in 2009 to make it more attractive to SMEs. The R&D tax credit is considered an important element in attracting foreign R&D investment.

Italy: One of the measures contained in the anti-crisis decrees are new tax benefits granted to enterprises, with an allocation amounting to circa EUR 2 900 million for the 2009-2011 period.

Lithuania: One of the most important novelties over the 2008-2012 period was the introduction of the corporate profit tax incentive for R&D and the corporate profit tax incentives for investments into new technologies in 2008-2009. Introduction of the tax incentives has put more emphasis on the innovation friendly environment.

Netherlands: the tax incentive support measure (WBSO R&D) - the largest measure in the Dutch policy mix, has been further broadened and extended. As of early 2010, companies can benefit from an effective tax rate of only 5% for income from intangible assets created by the Dutch taxpayer. It is no longer required that the intangible asset is patented and Technological innovations qualify for the Innovation Box.

Portugal: in early 2009, the Parliament approved a new scheme of fiscal incentives to R&D, extending the maximum rate of tax credit to 82.5% of total expenses on R&D. The tax incentive SIFIDE has been underlined by the present government as a very important instrument for encouraging business firms R&D expenditures and for contributing towards to the Barcelona 3% objective. It is interesting to remark that in spite of the financial difficulties the level of incentives granted under SIFIDE for fiscal year 2011 was higher than for 2010, including a credit for the recruitment of high-skilled staff. In 2012 benefits were reduced for large companies while for SMEs most of the conditions were kept unaltered.

Romania: In January 2009, a tax exemption was introduced in respect of dividends reinvested by the dividend payers, with the purpose of maintaining or increasing the number of jobs. Since December 2008, a supplementary 20% deduction in addition to the normal deduction obtained via R&D expenses was introduced. Machinery and equipment uses for R&D may also benefit from the accelerated depreciation method. In 2010 a law granting tax facilities to young entrepreneurs (up to 35-years old) setting up their first enterprise was approved by the Parliament who can benefit of salary and profit tax exemption for 3 years.

Slovakia: Since 2009 the Slovak government introduced an R&D tax stimuli. The R&D tax stimuli approved by the Slovak government accounted for about 0.3% spending by policy measures funded from the Structural Funds in period 2009-2012.

Slovenia: The level of tax subsidy has been increased in 2010 from 20% of allowed deduction of R&D expenses from corporate income tax to 40% of R&D investment regardless of the region where the investment takes place and to 60 % in the case of investment in a region 15% below Slovenian average GDP/per capita. From 2012 on the research tax subsidy is 100%.

United Kingdom: in 2011 the UK introduced the Seed Enterprise Investment Scheme (Seedeis), which offers tax efficient benefits to individuals while also encouraging investing in small and early stage start-up businesses in the UK. Seedeis was designed to boost economic growth in the UK by promoting new enterprise and entrepreneurship. The SME R&D Tax Credit was modified during 2012, raising the level to 225%.

Source: Erawatch 2012 country reports and further desk research on developments in 2013

R&D tax incentives have undergone a change of both volume and type. For instance, following the policy attention towards young innovative enterprises (YIE), France introduced a scheme where companies that benefit the YIE status become eligible for a series of tax rebates including exemptions on corporate earnings taxes, local taxes and social charges associated with the employment of highly qualified personnel. The scheme was reformed by the finance law in 2011.

While the effectiveness in stimulating business R&D is not yet proven, **R&D tax incentives have been claimed to be an appropriate choice during recession times** given the available empirical evidence that points towards a positive impact of tax incentives on R&D expenditures in the short term.

For example, the French Ministry for Higher Education stated that the Research Tax Credit has been effective in mitigating some of the consequences of the economic crisis, especially in tackling offshoring (Zaparucha, 2011). Moreover in France an econometric study found that the French Research Tax Credit had a positive impact on business R&D spending. According to the Ministry for Higher Education and Research the measure was instrumental in stabilising the level of business R&D investment in 2008 and a substantial number of businesses have increased their R&D expenditures as a result. In fact, 58% of businesses considered that the reformed R&D tax incentive encourages the increase of R&D expenditures; 34% recognise that it fosters joint research; and 29% that it encourages the hiring of PhDs qualified personnel.

In Slovenia the impact of the tax relief on investments in R&D was found to be positive, but it was stated that the instrument alone would not suffice for a more radical and durable R&D investment increase (IMAD Development Report, 2009). In 2010 the business sector increased its share in R&D investments to 58.4% although it did decrease compared to the peak in 2008. At the same time the R&D tax relief claimed by companies in 2010 continued increasing (IMAD Development Report, 2012).

Anecdotal evidence of the effectiveness of R&D tax incentives coinciding with the period of the crisis is found in Portugal, where despite the financial difficulties the level of incentives granted under SIFIDE for fiscal year 2011 was higher than for 2010, including a credit for the recruitment of high-skilled staff. The programme was evaluated by a commission nominated by the Minister for Science, Technology and Higher Education in 2005-2006 and his conclusions were positive. It was pointed out that SIFIDE had a significant contribution to induce business firms to carry out R&D activities (It is important to remark, however, that the above commission was not a fully independent one). Nevertheless, the suitability of tax incentives may not be that evident bearing in mind European countries with significant public debt, undertaking re-structuring processes of an uncertain time span and a weak STI system.

What a preliminary analysis of matching the presence of R&D tax incentives with trends in business R&D expenditure indicators tells us is that **countries with attractive R&D tax regimes are also among the countries with the highest government funding of business R&D through R&D tax incentives.** According to the Review of Global R&D tax incentives (Mazars, 2010), the European countries with attractive R&D tax regimes were France, Ireland, the Netherlands and UK (including also Israel, Australia, Canada and USA). Those countries also demonstrate a high percentage of the OECD indicator of estimates of government funding of business R&D through R&D tax incentives. Attractive R&D tax regimes may hence ultimately appeal to companies. Portugal and Spain are also positioned in the top 5 most generous EU countries according to the OECD's 2013 update of the B-index, but it is only Portugal that demonstrates a higher percentage of R&D funding through tax incentives compared to direct funding mechanisms.

Nevertheless no evidence of a positive relation between R&D funding through R&D tax

incentives and business R&D intensity exists (bearing in mind the limitations in composing the OECD indicator and the lack of data). This is also clearly demonstrated by the high business R&D intensity of countries like Germany, Finland and Sweden that do not use tax incentives (though Finland started in 2013 and Germany is investigating design options). Nevertheless from the countries that use tax incentives as part of their policy mix in the great majority of cases, business R&D funding has been resilient to the crisis. Exceptions include the UK and the Southern countries, Spain and Portugal.

Table 7: Resilience in Business R&D growth in the aftermath of the crisis (based on BERD as a percentage of GDP)

Countries using tax incentives	**Growth of BERD (2005-2008)**	**Growth of BERD (2008-2011)**	**Business R&D Growth pattern classification**	
France	2%	7%	resilient	Growth accelerated during financial/debt crisis
Ireland	15%	24%	resilient	
Czech R.	1%	29%	resilient	
Hungary	29%	42%	resilient	
Poland	6%	21%	resilient	
Lithuania	27%	26%	resilient	Growth remained stable
Denmark	18%	5%	resilient	Growth slowed down during financial/debt crisis
Austria	8%	1%	resilient	
Belgium	8%	2%	resilient	
Italy	18%	5%	resilient	
Netherlands	-12%	20%	positive reaction during crisis	Noteworthy positive shift during financial/debt crisis
Malta	-3%	33%	positive reaction during crisis	
Romania	-15%	6%	positive reaction during crisis	
United Kingdom	5%	-1%	negative reaction during crisis	Decline during the financial/debt crisis
Spain	23%	-5%	negative reaction during crisis	
Portugal	150%	-8%	negative reaction during crisis	

Lessons learned on the effectiveness of R&D tax incentives

The review of literature on the effectiveness of R&D tax incentives is diverse but there are some important lessons that recent evaluation reports and studies point out.

No single design as the most effective

R&D tax incentives have been used for a long time and while no robust empirical evidence exists there is anecdotal evidence of a positive impact on R&D expenditures. Nevertheless given the simultaneous support to business R&D provided through other direct mechanisms of support the interactions between the measures and their joint impact on R&D expenditures is difficult to split by support mechanism.

In the application of R&D tax incentives countries apply different approaches and there is no single design that stands out as most effective. We observe namely the use of either tax credits or tax allowances, either volume, incremental or a mix of the two. Anecdotal evidence suggests that there is a **preference towards volume incentives** – countries switching from incremental or from a mix of volume and incremental – which while entailing higher costs are often seen as simpler to implement. Based on the available literature, incremental R&D tax incentives have been indicated as being less effective. In fact, **incremental designs are assumed to be little effective**

during recessions when the market environment for additional R&D activities is unfavourable (NESTA, 2012).

The literature suggests that among the important factors to consider include: 1) the definition of the tax incentive – which activities are eligible considering the emphasis on non R&D innovation, 2) design – no clear superiority of a single design although volume designs are perceived as more attractive due to their simplicity while incremental designs are viewed as less effective than volume designs during recession times, 3) differentiations depending on size, age and length of usage of the support may be necessary depending on the objective of the intervention, 4) stability – uncertainty of the durability of the government support hampers decision to invest in R&D, 5) generosity – to influence decision making the support should be stimulating enough.

The conclusions of the CREST Working Group in 2005, following national needs and circumstances when deciding on the most appropriate tax incentive, still prevail: tax incentives should be easy to understand, stable in their design over time and transparent in order to reduce transaction costs as much as possible. When designing tax incentives, countries are advised to have broadly based approach to which companies, R&D topics and types and costs should be covered, thus stimulating the breadth of R&D within and across firms and not unduly differentiating between different types of firms. If the objective of the tax incentive is to increase the level of R&D substantially, and the associated loss of tax-revenue is acceptable, a volume-based tax-incentive seems to be the appropriate tool.

Assessing the benefits against the costs

While during a recession properties such as flexibility, low cost and broad reach of a support mechanism may be critical, **the appropriateness of R&D tax incentives to support business RDI is ideally evaluated by assessing benefits against the expected costs for governments.** There is however unfortunately limited evidence due to the lack of proper Cost-Benefit analyses (CBA) of existing R&D tax incentives capturing all direct and indirect costs and benefits. Limitations due to data availability and complexity in defining costs and potential benefits stemming from the application of R&D tax incentive mechanisms explain the absence of such studies. One difficulty for example in performing the CBA is forecasting costs especially when introducing an R&D tax incentive for the first time or when applying significant adjustments to it, given the uncertain reaction of the market.

Examples of reports explicitly mentioning over or under estimation we find in Austria and in Ireland. In Austria the budget for 2005 had been overestimated with the total cost of R&D funding at EUR 276.7 million versus forecasted figures of EUR 418 million. In Ireland the analysis of revenue data indicated that the take-up and corresponding cost of the tax credit have escalated considerably since the introduction of the payable credit in 2009 hinting towards potential underestimation of the costs.

Similarly, in Spain a recent analysis found that despite of a generous system of tax incentives for R&D and innovation, the bureaucratic procedure for benefitting from this measure has been complex and uncertain. The Ministry of Treasury has indicated that the average annual cost of tax income was EUR 200-300m in 2002-03 and over EUR 300-400m in 2004-08, decreasing to around EUR 200m in the last few years (Fernandez-Zubieta, 2012).

Despite the scarcity of CBA method based evaluations, there is however a substantial amount of research performed on the effectiveness of R&D tax incentives in terms of their contribution to increased business R&D expenditure – the so-called input additionality, using empirical evidence. There are both studies to claim that R&D tax incentive mechanisms are a useful tool to stimulate R&D expenditures, while others

are more critical. On the positive side there has been empirical evidence since the early 1990s that supports the effectiveness of R&D tax incentives. Research performed during the 2002-2007 period shows that at minimum R&D tax incentives produce at least one dollar of research for every tax dollar forgone (Atkinson, 2007). These studies namely examine the schemes put forward by a single country. Much has been written on the US, but also Canada, Australia, France and Spain. A significant and positive impact is also found in a study using time series from 1970 to 2002 (Falk, 2005; McKenzie and Sershun, 2010). More recent empirical literature using data from new or re-designed R&D tax incentive mechanisms is lacking. Recent extensive reviews of the literature (NESTA, 2012; Ientile and Mairesse, 2009) point out that results differ widely depending on the country, period, type of tax credit and practical implementation but also the methodology applied. [8][9]

Combining direct and indirect funding mechanisms

The final assessment of the appropriateness of R&D tax incentives to support business RDI from a policy mix perspective raises the issue of direct versus indirect support mechanisms. There is limited empirical evidence suggesting that one is more effective than the other. According to Dominique Guellec and Bruno Van Pottelsberghe (2000), the impact of direct government funding on business R&D is longer lived than that of tax incentives, reflecting the fact that government programmes target research projects with a longer time horizon than those on the agenda of business. A study using Canadian survey data (2005 survey in the manufacturing and logging sectors) found that firms that benefited from both R&D grants and R&D tax incentives introduced more new products than their counterparts that only benefited from R&D tax incentives (Bérubé, C., Mohnen, P., 2009). More recently the OECD suggested that **a transparent system of direct funding can be complementary to the use of R&D tax incentives** (OECD, 2013).

According to the latest Irish report on their R&D tax incentives, given the significant overlap in public support for R&D by companies in terms of grants and the tax credit, the public authorities involved should work closely to ensure that the policy outcomes of each of the different government supports are aligned (Airgeadais, 2013). In addition, the evaluation of the Austrian scheme compared the effects of fiscal incentives and direct subsidies for business R&D and found stronger effects for direct measures and particularly strong impacts for firms that used both types of government support (Falk, R., et al., 2009). In Lithuania although the data on the real uptake of the tax incentives are not available, the available data suggests tax incentives had become a strong alternative to the grants schemes. The interest in tax incentives for R&D has however slightly decreased over 2010-2011 (Paliokaite, 2012). In Slovenia the impact of the tax relief on investments in R&D was positive, but it was stated that the instrument alone will not suffice for a more radical and durable R&D investment increase (IMAD Development Report, 2009).

To optimise the mix between direct and indirect support the research and innovation system and framework conditions require careful assessment. Cases in which countries may turn to indirect forms of funding as a result of unsuccessful applications of direct measures of support without understanding of the underlying reasons may also jeopardise the applications of indirect mechanisms including that of R&D tax incentives. For example, in the case of countries with low absorption of funds, structurally long term low levels of business R&D expenditures and a limited pool of researchers and Higher Education Institutes undertaking research activities it is

[8] Moreover the empirical studies use different methodologies and modelling specifications and estimations which make it difficult to compare across studies. Hence, no certainty exists that the studies will produce the same outcome if replicated with the alternative methodologies available in the literature.

[9] For more details on the available literature see NESTA's Compendium, available at: http://www.nesta.org.uk

questionable whether R&D tax incentives would significantly improve the uptake of business R&D activities. At the same time a mapping of the innovation activity, technological vs non-technological, incremental vs radical or systemic, product/process/management innovation, is a prerequisite in the design of the mix of direct and indirect support measures.

Risk of supporting activities that would have taken place anyway

Assuming tax incentives are not exclusively viewed as temporary measures alleviating the impact of the crisis on business R&D the potentially high costs and risk of supporting companies who would perform R&D activities without the measure as well anyhow are aspects that need to be taken into consideration when defining the objective of the scheme bearing in mind country specific characteristics. On the other hand countries where R&D expenditures are structurally low R&D tax incentives may be used to change the behaviour of companies towards R&D or to attract R&D intensive companies from abroad. One illustration of this: in an earlier evaluation of the Dutch WBSO scheme which was said to have had a macro effect - increasing the structural level of R&D spending by business, the following distinctions were made: 50% of WBSO users said that it had some influence on undertaking R&D, 18% of users said it had decisive influence for undertaking R&D, 31% (with a large proportion being businesses with more than 200 employees) said it had no influence on undertaking R&D projects, 58% of users said that the level of R&D expenditure would have been reduced if the measure was not available to them.

Stability of R&D tax incentives

Evaluations of earlier support schemes point at the stability of support over time as a prerequisite for the attractiveness of R&D tax incentive support mechanisms. Whether supporting business R&D directly or indirectly or through a mix of instruments effectiveness is achieved when they are stable over time. Firms do not invest in additional R&D if they are uncertain of the durability of the government support (Guellec and Bruno Van Pottelsberghe, 2000). Bearing in mind that performing R&D is a long-term process, companies considering substantial engagement or expansion would evaluate risks differently assuming government support availability for many years and in a predictable and stable manner.

Within a globalised economy, other reasons why generous tax incentives may be preferred stems from their potential role in attracting and retaining R&D value adding companies. Cross-country variations in the generosity of tax incentives is said to influence decisions of large R&D players (NESTA, 2012). Though strong evidence supporting the hypothesis is lacking in Ireland for example the R&D tax credit since its introduction in 2004 is said to have influenced the decisions of many multinational firms to locate internationally mobile R&D projects in Ireland. IDA Ireland, the national agency responsible for foreign direct investment, estimates that over 40% of the projects it attracts into Ireland are R&D-related (TC, 2012). An attractive R&D specific tax regime is however only one criteria among many.

Differentiations by company size, age and years of use

While simplicity of design is needed so are differentiations by company size, age, years of use of R&D tax incentives depending on the desired impact and objective of the intervention. R&D tax incentives are ideally expected to appeal to all companies. In the UK, where a separate scheme for large companies and SMEs has been engineered, differences highlight that while R&D spending used to claim tax credits is driven mainly by the large company scheme, nevertheless the year-on-year increase in R&D expenditure was much higher under the SME scheme (13.9% versus 6.8% for those claiming under the large company scheme). In the Netherlands the 2007

evaluation of WBSO concluded that the effect on R&D expenditure depends on the size of companies, and the overall effect is larger in small companies.

Schemes that do not differentiate by size face the risk of under-usage by SMEs. In Spain for instance it was noted that tax incentives may only be used randomly by SMEs. Large firms, especially those that implement innovations, are more likely to use the tax incentives, while small and medium-sized enterprises encounter some obstacles to using them (Corchuelo, M.B., Martínez-Ros, E., 2010). In Austria companies with more than 100 employees make up the great majority of tax credits (although to a lesser degree than the 90% recorded for all allowances). The 2009 evaluation also notes that small companies seem to have little awareness of the structure of tax incentives for R&D and many of them complain about insufficient information. One good practice example addressing the latter point of awareness-raising can be found in the UK where an awareness campaign targeting innovative SMEs was launched in December 2012.

The age of the company may also require separate treatment when looking into whether start-ups may be disadvantaged in undertaking R&D activities through tax incentives. In France for instance, results of the survey on the R&D tax incentives scheme (CIR) underlined that young innovative companies are negatively impacted by the fact that the scheme does not consider anymore the increase in R&D spending. Innovative start-ups are characterised by an increase in their R&D spending during their first decade of existence, consequently 57% of young companies (under 5 years old) in the sector of Life Sciences are negatively impacted while large companies with fixed R&D amounts fully benefit from the reform. Finally, considerations of the need to differentiate companies that have used the credit for some time from newcomers (Guellec and Van Pottelsberghe, 2000) have also been discussed. It is hence reasonable to derive that some sophistication in the design of an R&D tax incentive mechanism is inevitable so as to realise fair treatment across the different beneficiaries.

Adopting a broader definition of eligible activities

It is finally important to note that R&D tax incentives according to the definition of the Frascati Manual, which is widely used by countries to define the eligible activities, do not capture non R&D innovation. The **potential benefit from R&D tax incentives may hence be limited for countries with limited capacity of business R&D unless adopting a broader definition of eligible activities.** For example, some firms have argued that the Oslo manual would be a better reference and others support the use of classifications used by a number of agencies (the DoD and NASA in the US, ESA in Europe) of nine 'technology readiness levels' (NESTA, 2012). Future applications of tax incentives with a more generous and strategic definition (i.e. in terms of sectors like the case of green technologies in Belgium) of eligible activities would in today's context seem more appropriate in stimulating innovation and potentially influencing behaviour. The higher costs approach may need to be investigated in depth and compared with other direct measures of support.

4.4. Consequent policy-making and flexible policy measures

Although some of countries turned towards alternative policy instruments to maintain research and innovation activities, the review of measures and evaluations reports point to the importance of **stable or flexible innovation policy measures that have been continued to finance innovation in a consequent manner**. Innovations can happen under pressure; however, businesses need certain stability in terms of the business environment in order to keep on focusing longer-term goals instead of short-term survival.

The analysis of monitoring and annual reports of innovation policy measures reveal that in some of the countries on-going innovation support programmes contributed to mitigate the impact of the crisis on innovation activities. Many such examples come from countries such as Austria, Denmark, Germany or Sweden (although it has to be kept in mind that the crisis had a less severe impact on the macro-economic conditions), but the cases of Ireland and Portugal also underpin this argument.

Moreover, the most recent innovation policy country reviews have cited the relevance of the Structural Fund programmes which also brought a certain kind of stability in the innovation system as specifically these funds were usually the ones that kept on going. This was for instance important in the Czech Republic, Estonia, Latvia, Slovakia, Slovenia, Romania or Poland.

The key policy measures of the German 'growth policy' launched in 2010 have been the Central Innovation Programme (ZIM) and the SME Innovative (KMU Innovativ) Programme. The ZIM awarded grants to over 9000 SMEs from mid-2008 to the end of 2011. For the majority of SMEs, the funding they received enabled them to expand their company's technological base and recruit additional R&D personnel. The German Institute for Economic Research (DIW) conducted a study on the effectiveness of the German SME innovation support programmes in 2011. The DIW study concludes that the innovation support programmes provided to SMEs contributed to preserve innovation activities of SMEs also during the global financial and economic crisis. Investment in innovative projects helped short-term adjustments. **The ZIM programme most probably contributed that SMEs did not cut R&D expenditure between 2007 and 2009. Furthermore, the continuity of project funding provided SMEs with planning certainty.** The analysis conducted on the basis of DIW Berlin's survey also indicates that government funding did not replace a company's own R&D investment but rather complemented it. The German 'growth policy' aimed to preserve attractiveness as a location for business and innovation, to create sustainable new jobs and to safeguard prosperity for future generations. This meant first of all an increase in the amount of funding: the total innovation funding was EUR 1.5 billion in 2011, double of the amount of 2005. Around half of this went directly to the SMEs, while the other half was used to finance the SME-related research infrastructure (DIW, 2011).

In Austria the FFG General Programme of the Austrian Research Promotion Agency has been Austria's most important source of public funding for research and development activities carried out by industry. It promotes R&D in all economic sectors and branches, all areas of technology, and all sizes of companies. In 2008, the value of the subsidies of the FFG amounted to approximately EUR 421 million. **The Austrian economy has become increasingly active, especially at the beginning of 2009 in research and development in order to dive through the on-going economic crisis** and to prepare for future competition. As the FFG Annual Report found 8% more applications arrived in 2009 than in 2008.

The Danish Business Innovation Fund was established in 2009 under the Danish Ministry of Business and Growth. The aim of the Business Innovation Fund is to promote growth, employment and export by supporting business opportunities within green growth and welfare as well as providing support to exploit new business and growth opportunities in less favoured geographical areas of Denmark. The Business Innovation Fund differs from other business support schemes by virtue of its focus on the SME segment and its support to market introduction of new products and services. The projects are still at an early stage where it is not possible to measure directly whether the expected effects are likely to be realised. **The review of the measure showed that the fund helped companies overcome critical barriers in order to achieve success such as access to capital and customer confidence in new**

products. The activities of the Fund were also found to be profitable in economic terms.

The Business Innovation Fund was reorganised in 2012 and the **Market Development Fund**[10] has become its successor. The Market Development Fund is intended to build on the lessons learned from the market development activities conducted by the Business Innovation Fund. **The particularity of the Fund is its close-to-market, enterprise-oriented and commercially focused feature.** It is a demand-side measure since it seeks to assist Danish enterprises in overcoming the barriers encountered in the market development phase, e.g. by providing co-funding for the testing and adaptation of an enterprise's innovative prototypes on-site for prospective customers or by providing a guarantee to give peace of mind to the buyer of an innovative new product.

Innovation Voucher schemes have been found as an important instrument to finance and stimulate business innovation in the times of the crisis. The Irish Innovation Vouchers have been seen as a success: 500 innovation vouchers were redeemed in 2010, and this number increased to 518 in 2011. The available data from Enterprise Ireland indicates that there has been a large take-up by small enterprises of the scheme. In 2010, a total of 489 vouchers were redeemed at a cost of EUR 2.4m. In Lithuania the results of the voucher scheme suggest high demand for this type of instrument. One of the major success factors has been the simplicity of its administration ('quick money' for business R&D). Portugal and Hungary had similar experiences, where the Innovation Vouchers measure had a good take-up and show good project results. Nevertheless the example of Greece shows that there might also be important barriers that can hamper the effectiveness of such schemes. The Greek Innovation Voucher scheme has been lagging behind in terms of the number of supported companies and the provided funding.

4.5. European dimension in enhancing innovation-based growth

The majority of European initiatives put in action before the economic crises hit, continued without adjustments in their focus and objectives. The aspects of RDI activity hampered by the recession as experienced across EU countries - business RDI, exports of innovative products and services, access to finance for businesses i.e. venture capital, patenting, albeit to a different degree from no impact to severe impact, were by design accounted for in the different European initiatives.

In fact, the evaluation of the Competitiveness and Innovation Programme (CIP) noted that the crisis has underlined the significance of the central objectives and the relevance of many of the issues CIP was designed to address (support for innovation in SMEs; improved SME access to finance and provided personalised and professional services; pilot projects on thematic priorities of eco-innovation, ICT-based services and sustainable energy, etc.).[11] With regard to the support of young innovative companies, the EU state aid rules for research and innovation introduced more favourable treatment for these companies.

Another example is the Risk-Sharing Finance Facility (RSFF) with the main objective to improve access to debt financing for all types and sizes of private companies and public institutions undertaking RDI projects (complemented by the Risk Sharing Instrument for Innovative Research oriented towards SMEs & Small Mid-Caps (RSI)). Based on the 2009 evaluation, the RSFF loan provided a stabilizing employment factor and avoided a brain drain of highly qualified people, which had been anticipated as a consequence of the financial crisis. In terms of its effectiveness the financial crisis in

[10] http://markedsmodningsfonden.dk/in_english

[11] For more details see: http://ec.europa.eu/cip/files/docs/factsheets_en.pdf

2009 has led to a significant increase in RSFF activity, which however seemed more 'volume' than 'innovative/quality'-driven.[12] The Risk Sharing Instrument (RSI), developed by the European Commission in partnership with the European Investment Bank Group, will help small firms gain access to finance by guaranteeing some of the risk that banks take on through their lending.

Other running European initiatives were further enhanced either to cover the demand in excess or to heighten support to SMEs or to thematic priorities, irrespective of the crisis but during the period of the crisis (see Table 8).

At European level, the European Economic Recovery Package explicitly targeted access to finance through the increase of EIB's yearly interventions by some EUR 15 billion for the period 2009-2011 in the form of loans, equity, guarantees, risk-sharing financing and the generation of a positive leverage of additional investment from private sources. It was complemented by the European Bank for Reconstruction and Development (EBRD), which also added EUR 500 million per year to its present level of financing in the new Member States. The initiative delivered more than EUR 20 billion of the planned EUR 30 billion in additional loans to SMEs that it agreed to provide.[13] Under the European Economic Recovery Package, sector specific support was provided, targeting those experiencing a dramatic fall in demand during the initial phases of the financial crisis, which also faced significant challenges in the transition to the green economy (FP7 - Research PPPs). Nevertheless, the aforementioned interventions are broader in their coverage of activities supported and thus go beyond R&D&I activities.

Table 8 EU initiatives

Initiative	**Description-short**	**Boost during the crisis**
EUREKA 1985-ongoing	Intergovernmental network launched in 1985, to support market-oriented R&D and innovation projects by industry, research centres and universities across all technological sectors	Increased budget of the follow-on programme of Eurostars - estimated three times higher than its predecessor.[14]
FP7 2007-2013	Cooperation and Capacity Programmes	There was a significant increase in EU contribution going to SMEs for all thematic priorities after 2011. This is because many work programmes of 2011 and 2012 included measures designed to increase SME participation, such as ring-fenced budgets, or the inclusion of topics of special interest to SMEs, etc.[15]
Jeremie - Joint European Resources for Micro to Medium Enterprises	Finance small and medium-sized enterprises (SMEs) with the opportunity to use part of EU Structural, by means of equity, loans or guarantees, through a revolving Holding Fund acting as an umbrella fund	Its use peaked in 2010 with nearly EUR 11bn in signatures, equalling 17% of total signatures that year The last three years (2009-2011) account for 43% of the total FL EUR 55.1bn signed amount.[16]

[12] For more details see: http://bei.europa.eu/attachments/ev/ev_rsff_en.pdf.
[13] For more detail see: http://www.eib.org/attachments/general/bei_info/bei_info138_en.pdf
[14] For more details see: 2012 Annual Report EUREKA http://www.eurekanetwork.org
[15] For more details see: 2013 SME Participation in FP7 report, http://ec.europa.eu/research/sme-techweb
[16] For more details see: 2013 JEREMIE evaluation (2000-2011) http://bei.europa.eu

5. Country patterns in policy approaches and scenarios for the future

5.1. Review of the latest policy trends

The latest economic reviews convey a positive message about the process of fiscal consolidation in the Eurozone in the upcoming years; however, they also warn that the on-going recovery may remain fragile and sluggish unless measures are taken to raise investments to support the economy (EC, 2013). Investment prospects are still grim; banks have a stricter lending strategy and both access to finance and the availability of venture capital is low. Excessive private borrowing, household debt and overleveraged firms further threaten to slow down economic recovery. Public budgets in many countries are expected to stay tight, which is also affecting manoeuvre room for research and innovation policies. On the other hand, as a recent French policy paper also notes: "it is not about spending more money on innovation but using it differently and in a more efficient way."[17] Hence, a better and more effective organisation of innovation policy will continue to be important.

As the country analysis will discuss later, there are several common patterns which shape the national research and innovation policy and policy mix in the upcoming period. This analysis identified three possible scenarios: 1) *modus operandi* – meaning that there won't be many changes in the policy and policy mix as compared to the previous period; 2) *empty pocket* – referring to the situation of some countries where R&I budgets are cut and where there will be a need for reorganisation of the innovation governance and finding alternative ways to finance innovation; 3) *long-term commitment* – there is a clear commitment towards an innovation-based growth in some countries, which will continue with some of the well functioning measures and will pilot new types addressing demand-side policies or internationalisation.

Table 9: Scenarios for research and innovation policies in 2014-2020

Scenarios	Countries
"Modus operandi"	Czech Republic, Hungary, Lithuania, Malta, Poland, Slovakia
"Empty pocket"	Bulgaria, Cyprus, Greece, Italy, Latvia, Portugal, Romania, Slovenia, Spain
Long-term commitment to R&I policies	Austria, Estonia, Germany, Denmark, Finland, France, Ireland, Luxemburg, the Netherlands, Norway, Sweden, Switzerland, UK

Notes: Based on analysis of national trends in research and innovation policy

Countries across the EU are expected to give different responses to the crisis in terms of their research and innovation policies depending on their research and innovation policy history, their industrial profile, the severity of their public sovereign debt and on their economic conditions. Table 10 and the following brief country summary give an overview and more specific insight into the most recent hot topics.

[17] Report of Jean-Luc Beylat and Pierre Tambourin: L'innovation un enjeu majeur pour la France, 2013

Table 10: National R&I policies in the aftermath of the crisis

Crisis	***Country***	***Trends in R&I public funding (2013/2014)***	***Expected scenario and trends in policy***
Hit the hardest by the financial crisis	Cyprus	Budget cuts	"Empty pocket" - Improving governance, access to finance
	Greece	Budget cuts	"Empty pocket" - Improving governance, access to finance
	Ireland	Budget cuts	"Empty pocket" - Emphasis on commercialisation of research and start-up enterprises, with a more targeted policy
	Italy	Budget cuts	"Empty pocket" - More emphasis on tax incentives, loan-based schemes and venture capital
	Portugal	Budget cuts	"Empty pocket" - More emphasis on loan-based schemes, venture capital and internationalisation
	Slovenia	Budget cuts	"Empty pocket" - More emphasis on tax incentives and loan-based schemes
	Spain	Budget cuts	"Empty pocket" - Science and industry linkages, improving framework conditions, more emphasis on tax incentives, and venture capital, internationalisation
Severe consequences of the economic and/or the sovereign debt crisis	Bulgaria	Budget cuts	"Empty pocket"
	Croatia	Budget cuts	"Modus operandi" Improving governance, increased importance of Structural Funds
	Czech Republic	Budget protected	"Modus operandi", more focus on commercialisation of research results, venture capital measures
	Finland	Budget protected	"Committed" Focus on business innovation, venture capital and entrepreneurship
	France	Budget protected	"Committed" identification of 34 innovation areas, improving framework conditions
	Hungary	Budget cuts	"Modus operandi", more emphasis on start-up funding and entrepreneurship
	Latvia	Budget cuts	"Empty pocket"
	Lithuania	Budget protected	"Modus operandi", more emphasis on tax incentives and loan-based schemes
	Netherlands	Budget cuts	"Committed" selecting 9 top sectors with more focus on loans and venture capital
	Romania	Budget cuts	"Empty pocket" - more emphasis on tax incentives and loan-based schemes
	UK	Budget protected	"Committed" selecting thematic and technological targets, more focus on entrepreneurship, loans, venture capital
Less severely affected by the crisis or recovered quickly	Austria	Budget increase	"Committed" with more focus on venture capital
	Belgium	Budget protected	"Committed" with more focus on commercialisation of research results
	Denmark	Budget increase	"Committed" More focus on business innovation and entrepreneurship
	Estonia	Budget increase	"Committed" with a more targeted approach, more emphasis on loan-based schemes, international cooperation and scientific excellence
	Germany	Budget increase	"Committed" with more focus on venture capital
	Luxemburg	Budget increase	"Committed" Continuing policy
	Malta	Budget protected	"Modus operandi"
	Norway	Budget increase	"Committed"
	Poland	Budget protected	"Modus operandi" Strengthening science and industry linkages, more focus on financial engineering
	Slovakia	Budget protected	"Modus operandi" with a stronger focus on financial engineering
	Sweden	Budget increase	"Committed" Commercialisation of research results, demand for innovation, globalisation
	Switzerland	Budget increase	"Committed"

As the above table also shows, the country R&I policy approaches taken in the aftermath of the crisis tend to show some common patterns in terms of the severity of the crisis, their geographical situation and development path of research and innovation policies. It is not surprising that countries that are less influenced by the consequences of the crisis have managed to increase or keep at the same level their research and innovation public budgets. Countries most affected could not keep their research and innovation funding and had to cut their budgets although this is happening to different extents. Among countries that are influenced by the worsening market conditions or the tightening public budgets due to debt we find different scenarios.

One observation is that although there are countries that are severely influenced by the consequences of the crisis, they are striving for a bolder innovation strategy and put in place policy measures to support innovation (eg Ireland, Lithuania). The following section gives an overview of the country patterns.

Countries hit hardest by the crisis

In **Cyprus, Greece, Portugal, Italy, Slovenia and Spain,** the economic and financial crisis has left a strong mark on research and innovation policies as it shifted the attention of government on macroeconomic stabilisation while research and innovation have become rather an 'orphan' in the highest political discussions. Only Ireland (and to some extent Spain) in this group that has been hit hard by the crisis but has been taking important efforts to protect research and innovation public spending and to keep this topic as prominent on the policy agenda. In Slovenia, even if the crisis hit later as in the other countries in this group, it currently faces serious setbacks.

As the debt burden is not yet easing, the key challenge in these countries is how to find a way to support R&I in times of austerity and financial restrictions. The crisis has a further implication on the research and innovation governance which must be improved in order to raise efficiency and clarity in the innovation system. For instance, the Slovenian R&D and innovation system is not just faced with a challenge of lower financial resources, but this is combined with a lack of clear policy focus (Bucar, 2012).

Another pertinent issue is that as investment in science is declining, the spending and salary cuts negatively influence researchers and highly skilled career prospects, which in turn is resulting an outmigration of talented young people. This can cause an irreversible weakening in these countries' research and innovation systems.

A common response of this group of countries has been to seek alternative financing mechanisms such as strengthening or adjusting R&D tax incentives, stimulating venture capital through state-backed funds and turning to loan-based schemes. In Italy the policy measures introduced aimed to implement indirect incentives, such as tax credits to the business sector, to promote new modalities of financing innovation especially for SME, such as venture capital, to reform public funding for research and introduce some budget cuts in the framework of stabilisation of the overall government budget (Nascia, Poti and Reale, 2012).

Especially in Ireland, Portugal and Spain a critical topic is how to better use international financing sources for R&I given that domestic resources are drying up.

Even if some of the macro-economic framework conditions are similar, the individual policy approaches towards research and innovation differs and will be analysed in more detail in a specific country group case (please see Chapter 6.1).

Countries that face serious consequences of the crisis

The **Dutch, French and British** policies seem to follow a similar policy approach in terms of research and innovation. They also have a traditionally similar policy mix. Each of these countries plans to continue and strengthen on-going policy measures such as R&D tax incentives, knowledge transfer partnerships or financing schemes to business innovation. Their research and innovation policies are also expected to be refocused on areas or technologies with high economic and growth potential. The UK selected key emerging technologies with strong economic potential on which funding will be concentrated. Financial support to SMEs and entrepreneurs is planned to increase. The French government has initiated an exercise to identify and anticipate technological areas that future competitiveness can be built on. This resulted in a plan of 34 areas including, for example, renewable energy or the digital hospital. In the Netherlands the policy mix is focused at increasing the R&D intensity of the Dutch business sector, especially via the 'top sector' approach.

In **Hungary, Latvia and Lithuania** research and innovation policy is less of a priority. Although these countries prepared the recent strategies, there is not much change to be expected compared to the previous policy mix. Their R&I policies are also very much determined by the preparation of Smart Specialisation Strategies. They face some key pertinent issues such as the brain drain of researchers and innovative workforce. It is claimed that there has been an overreliance in EU Funds but there is no domestic funding to continue research. The evolution of the current policy mix is expected to remain focused on R&D policy, based on EU Structural Funds, and to continue the path of the previous operational programmes. In the **Czech Republic** the RDI policy mix is likely to focus on the support of innovative companies, RDI human resources development including - mobility issues, international as well as inter-sectoral co-operation in research, securing the sustainability of the large research infrastructures and the design of a new evaluation methodology of R&D results. The case of the Czech Republic, Hungary and Poland will be further analysed in Chapter 6.2.

Bulgaria and Romania are two countries that have experienced a recent inflow of Structural Funds into research and innovation policy. They depend heavily on the available EU funding for R&I. One key challenge is that there is no clear match between the national priorities and the structural challenges.

Countries affected less severely by the crisis

The **Polish and Slovak** research and innovation policies rely to a large extent on Structural Funds and are expected to continue their modus operandi. Poland put a much stronger focus on science-industry linkages continuing a trend that started earlier. The Polish and Slovak policy plans show similarity in terms of planning to introduce new loan-based financial engineering models. The Slovak Ministry of Economy drafted a new law on subsidises to enterprises, which introduces a new target for the government intervention – industry research, experimental development and innovations. Incumbent legislation so far recognised five areas of government intervention: mining, energy sector, small and medium enterprises, manufacturing, services and consumer protection. Trends show increased direct allocation of funds to firms, a stronger focus on financial engineering, namely venture capital, and the opening of new credit lines for firms with investment projects already approved (Balaz, 2013).

Among the performers that show good results in terms of innovation performance and have been less influenced by the negative impacts of the financial crisis (although of course the economic crisis affected their national innovation systems as well) are Austria, Germany, Estonia, Denmark and Sweden.

Austrian and German innovation policy builds upon traditionally strong innovation policy measures with long history, and this is planned to continue. Their policy mix is not expected to change although there are discussions about supporting more venture capital funds and start-up activities.

Estonia recently adopted the R&DI strategy 2014-2020 and the Entrepreneurship growth strategy 2014-2020 (2013). They both focus on shifting the economic structure towards a more knowledge-based economy, on scientific excellence and serving the economy through increasing the quality of human resources, motivating business, and science collaboration and internationalisation. The most important change in the new R&D and innovation strategy is the focus on building human resources capacity. Secondly, the Ministry of Education and Research defines itself as being in the second position after the sectoral ministries who are expected to drive the research and innovation agenda. Even though this approach can be considered as forward-looking and successful, in the long run it will require a fundamental change to the current mind-sets of stakeholders (Eljas-Taal, 2013). In addition, the trend to move from grants toward financial instruments, loans and guarantees is being been discussed as a tool for a soft phasing out from Structural Funds support.

Denmark, Finland, Norway and Sweden face structural challenges and are very much influenced by globalisation. Their strategy is centred on societal challenges and user-driven innovation. They also show similarities in terms of preparing global innovation plans and addressing the potential in global linkages strategically. But there are also important differences. As long as in Sweden research is traditionally has been important and the focus is on commercialisation of research results, the Danish and Finnish innovation policy show trends towards business innovation and entrepreneurship.

Although their research and innovation performance indicators might suggest a positive picture in these countries, one has to keep in mind that they also face structural challenges and have to take the right steps to reach a competitive position on the dynamic markets of the future.

Summarising the key challenges of national research and innovation policies

What are the key questions that will guide and influence the future research and innovation policies? We list below five identified based on the country analysis, though the list is far from being exhaustive.

- What are the alternative ways to finance innovation?

These questions are being discussed across all countries for different reasons: in the countries hit hard by the crisis alternative financing mechanisms could bring relief on the public budget purse. In countries where research and innovation policy is being financed by SF mainly it could offer alternatives for phasing out and relying more on domestic sources. Furthermore, a more buoyant venture capital market could foster entrepreneurship.

- How to foster a new specialisation in higher technology level industries and how to raise the growth dynamics of innovative firms? How to raise more demand for innovation?

The crisis amplified the problem that many countries have only a weak basis of new technology-based or (emerging industry) firms. Although it is relevant across all EU Member States, the most recent research and innovation strategies for instance in Denmark, Finland, France, the Netherlands and UK take steps to anticipate new growth areas and create new specialisation patterns in high-tech innovative industries.

- How to stop brain drain?

In several countries where the economy was hit hard by the crisis, the problem with the supply of a qualified labour force for R&D and innovation sector has become particularly acute due to foreign brain drain. This is happening in Greece, Italy, Portugal and Spain (where researchers also have to face salary cuts), and it is also a serious issue in Hungary, Latvia and Slovenia (where many talented people leave to find better prospects and high level jobs abroad).

- How to take advantage of the potentials of globalisation?

Globalisation offers a new source and potential new demand for innovation. Solving societal challenges and developing new solutions that can be later on sold world-wide is a part of the strategic thinking in many countries, for instance in France, Finland, Denmark, Sweden and UK. Future research and innovation policies show some shifts in this respect, where internationalisation and positioning the innovation system globally gets stronger attention. In countries like Sweden or France the internationalisation efforts are also very much linked to cluster policies.

- How to use Structural Funds smarter and how to live without the Structural Funds and EU Funds to support research and innovation?

In many countries no substantial changes are expected as compared to previous programmes that have not resulted in any change in innovation performance. Despite the good intentions in smart specialisation strategies, and the in many cases serious work ongoing, it is questionable that the concrete implementation will make a real change. In many countries, there are voices of 'modus operandi' meaning that it is not expected that the new programming period would bring the crucial and important changes as would be necessary.

Related to the previous question, Member States now relying too much on Structural Funds have to start planning how to find different mechanisms to finance research and innovation. It is a real threat that the overreliance and not adequate utilisation of European funds will undermine the future of a more competitive and sustainable economy.

5.2. Looking into the future – a statistical prospective analysis

Complementing the reflection on the trends that can be expected in the upcoming period, a prospective analysis has been tested on different research and innovation performance and policy indicators. The main purpose of the prospective analysis part of this study is to answer the following questions:

- Is there a long run empirical relationship between the main economic and RDI performance indicators?
- If such a relationship exists, what are its characteristics?
- What would be the effects of the major shifts in the key policies from the standpoint of this long run relationship?

Applying co-integration analysis we investigated how main economic and RDI performance indicators move together through time (Greene, 2003).

Co-integration between different variables naturally arises in economics. Co-integration is most often associated with assumptions that imply equilibrium relationships between time series variables. In particular, the growth theory models imply co-integration between investment and economic output, with productivity improving (technological) changes being the common trend. The equilibrium relationships are referred to as long-run equilibria, because the main economic drivers that move in response to sudden shifts may take a long time to bring the system into equilibrium again.

In this study we imply the presence of a long-run equilibrium relationship between the macro-economic inputs into the innovation process (such as business and government R&D expenditures) and its main outputs (represented, for example, by patents and/or commercialisation activities). We assume that such a relationship can represented by a single cointegrating equation.

This assumption reflects a view at innovation as an investment opportunity, which requires commitment of time, financial and intellectual resources to achieve a result. Griliches (1979) and Crépon, Duguet, and Mairesse (CDM, 1998), and Hall (2002) state that the primary output of R&D investment is knowledge of how to make new goods and services.

We further consider the changes in policies as the main driving forces behind the shifts, which influence the equilibrium between the innovation inputs and outputs. Looking at the long-run reaction of the co-integrating series we then can make conclusions about the possible effects of different policies on the RDI performance in European countries.

Indicators

At this stage the following indicators have been used for the prospective analysis:

- Total Business expenditures on R&D (BERD) per inhabitant;
- Total government expenditures on R&D (GBAORD) per inhabitant;
- Total number of patents as a measure of innovation output;
- R&D personnel in number of FTEs as the main resource for innovation;
- Volume of venture capital financing in millions of euros as a measure of commercialisation activities.

The R&D personnel indicator is available on quarterly basis. For other variables we have calculated the corresponding quarterly levels.

Scenarios

Based on the estimated empirical long-term relationships and following the national innovation policy trend analysis presented in the previous section, we considered several general policy change scenarios compared to the baseline scenario of keeping status quo:

1. Moving towards loan-based financing (which is represented by a positive shift in BERD and a relatively stable GBAORD in long term);
2. Stopping all Structural Funds funding innovation policy (decrease in GBAORD in countries/beneficiaries of the Structural Funds programmes);
3. Strengthening demand-side instruments/procurement (increase in both BERD and GBAORD).

In order to assess each of these scenarios quantitatively it is necessary to link them to the corresponding movements in the variables used in the model.

In the framework of the cointegration relationship modelled by a single equation we can consider the effects of each scenario by observing the impulse response functions showing the reaction of other variables on the sudden increase of a given factor.

When considering the policy case of moving towards loan-based financing we rationally expect that these policies in the long run will not have an effect on the GBAORD because when granting support the decision makers should aim at achieving an acceptable rate of loan repayments (ideally resulting in at least zero return

overall). At the same time, it is expected that the favourable interest rates for such loans and the availability of extra support should stimulate firms to invest more in their R&D, thus giving a positive impulse to BERD. Therefore the effects of such a policy shift can be seen in the response functions describing the effects of positive changes in BERD and GBAORD.

In the policy shift resulting in a substantial scaling down of Structural Funds, the effect is expected to manifest itself in a decrease of government R&D expenditure, as the national budgets loose an important inflow. Thus, here we will look at the impulse response functions describing the effects of shifts in the BERD variable.

When looking at the scenario of strengthening the demand side policies one would expect that the national governments make more funds available to the firms in the form of both subsidies and loans. Thus, at an aggregate level such a scenario should lead to an increase in both BERD and GBAORD.

In general the intuition tells us that under normal condition there should be a positive relationship between the R&D inputs and R&D outputs, which in its turn should have a positive relationship with RDI enablers.

Methodological limitations

Despite its conceptual simplicity, this analytical setting does have its limitations. Firstly, this co-integration analysis relies on the assumption that in a given country the innovation outputs are driven by a common (technological) development trend. In the case of the European economy such a common technological trend is represented by a common structural shift in the economies of most Member States towards more technology intensive and complex products. But in different Member States this trend exhibits different patterns and power. Secondly, the length of the time series used in this analysis is rather limited due to the fact that the innovation statistics (especially that about the business expenditures on R&D) has been systematically collected since recent time (from 2005 with the most recent data available for 2010-2011).

The employed modelling procedure does take into account the short time span of the series and performs a small sample correction for critical values used in hypothesis testing[18] (as proposed by Johansen (2002)). Particular details of the modelling process are presented in appendix.

In general, we advise caution when interpreting the results of this analysis. First, of all the co-integration analysis is deeply rooted in statistical properties of the series and it does not claim a clear identification of causality. Second, it is advised to look at these results as a qualitative indication about the signs of inter-dependencies rather than the actual point estimations of marginal effects. Finally, the results below describe the relationships estimated in the framework of individual cases/countries and thus cannot be projected on other Member States.

Modelling results

The available data (mostly limited by availability of information on venture capital financing) allowed us to carry out the prospective modelling for 18 countries from the original list. Among these countries we have all 6 countries from the list of comparative case studies and a selection of other countries, which are predominantly the 'older' Member States.

In the Box below we present a short description of the modelling procedure and how the main results about the effects of different shifts in main policy variables were obtained and interpreted.

[18] Stata Manual, http://www.stata.com/manuals13/tsvec.pdf

Box 4: Co-integration analysis

Interpreting results

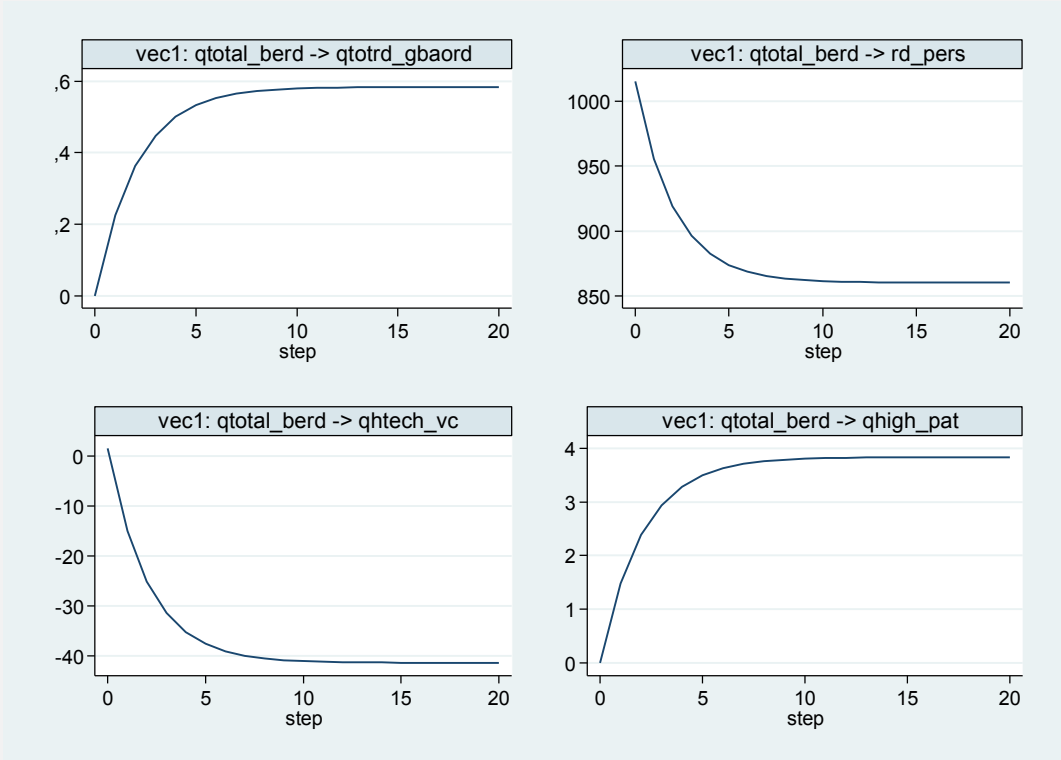
The co-integration analysis in this study departs from the assumption of a single co-integrating relationship between the innovation input and output indicators.

In the first step the series have been tested for unit roots in order to conclude about them being non-stationary, which is an important assumption behind the existence of a co-integrating relationship. The individual series were tested using the Dickey-Fuller test with a null hypothesis of a unit root being present. For each country the DF-test results were presented in a table, where the cases of not rejecting the unit root are highlighted as favourable (see example of Spain below).

	Unit root test significance
GBAORD	>5%
BERD	>10%
R&D personnel	>10%
Venture Capital	>10%
Patents	>10%

When the co-integrating relationship has been identified and estimated we focus on the estimated impulse response functions as the main information source for assessing the effects of different policy scenarios.

From the example of impulse response functions representing the reactions of the system on shifts in business R&D (BERD):



we can conclude that an increase in BERD in most likely to have the following long-term effects (projected as a forecast 20 period/5 years ahead):

- increase in GBAORD;
- increase in the R&D personnel (the effect gets weaker over time though);
- decrease in venture capital fiunancing;
- increase in patenting.

A similar set of impulse response functions has been calculated to corresponding shifts in GBAORD.

Table 11: Qualitative representation of the effects of positive shifts in GBAORD based on the estimated impulse response functions (+ corresponds to an increase in the series and – corresponds to a decrease, for details see the Box above and the Quantitative Annex).

Long term effects of shifts in GBAORD on	**BERD**	**R&D personnel**	**Venture Capital**	**Patents**
Austria	+	+	-	+
Belgium	+	+	+	+
Czech Republic	+	+	+	+
Denmark	+	+	+	-
Finland	-	-	-	-
France	-	-	-	+
Germany	+	+	-	-
Greece		+	+	+
Hungary	-	-	+	+
Ireland	+	+	+	-
Netherlands	-	-	-	-
Norway	+	+	+	-
Poland	+		+	+
Portugal	+	+	+	-
Romania	+	-	+	+
Spain	+	+	+	-
Sweden	+	+	+	-
United Kingdom	+	+	+	-

Table 12: Qualitative representation of the effects of positive shifts in BERD based on the estimated impulse response functions (+ corresponds to an increase in the series and – corresponds to a decrease, for details see the Box above and the Quantitative Annex).

Long term effects of shifts in BERD on	**BERD**	**R&D personnel**	**Venture Capital**	**Patents**
Austria	-	+	+	+
Belgium	-	+	+	+

Long term effects of shifts in BERD on	BERD	R&D personnel	Venture Capital	Patents
Czech Republic	+	+	-	-
Denmark	+	+	-	+
Finland	-	+	+	+
France	-	+	-	+
Germany	+	+	+	+
Greece				
Hungary	+	+	-	+
Ireland	-	+	-	-
Netherlands	+	+	+	+
Norway	+	+	+	+
Poland	-		+	-
Portugal	-	+	+	+
Romania	+	-	+	+
Spain	+	+	-	+
Sweden	-	+	+	+
United Kingdom	-	+	-	+

From the assessed effects of changes in GBAORD and BERD presented in Table 11 and Table 12 we can make the following summarising conclusions:

- The effects of policy changes leading to an increase in GBAORD are more likely to be associated with an increase in business R&D, R&D personnel and venture capital financing.
- The link between the GBAORD increase on patenting appears to be mixed with multiple positive and negative results observed. It appears that an increase in GBAORD is likely to be accompanied by an increase in patenting in the "modus operandi" group of countries, and by a decrease in the countries that were hardest hit by the crisis. Furthermore, such a decreasing pattern is also observed in most old Member States indicating the current level of state support to R&D and innovation has probably exhausted its patenting stimulating potential.
- A positive shift in BERD is likely to result in a positive reaction in the R&D personnel variable and in patenting. The positive effect of shifts in BERD on patenting is observed in different country groups, which allows us to argue that the policy actions that stimulate private R&D and not necessarily involve increase in government R&D are still likely to encourage patentable innovation activities.
- The venture capital financing appears to react in a mixed way to positive changes in business R&D. We expect the positive shifts in business R&D to be accompanied by the positive shifts in VC financing in countries least affected by crisis (such as Germany and the Nordic countries). For the rest of Member (and Associate) States no common pattern has emerged. This result indicates that the relationship between the R&D inputs and enablers is not straightforward. Furthermore, the availability of venture capital during the times of crisis is also strongly influenced by factors not related to the RDI system, such as the health of financial system and government finances.

When looking at the policy scenarios described above, the conclusions for some scenarios are more confident than for the other:

- Scenario 1 "Moving towards loan-based financing" is likely to be associated with an increase in a number of R&D personnel and rather likely an increase in patenting activity. It is possible to expect that the more resilient countries will also exhibit an increase in commercialisation that attracts VC, while for the countries from other groups results remain mostly country specific.
- Scenario 2 "Stopping all Structural Funds funding" is likely to be associated with a decrease in R&D personnel and inhibit the country' innovation output represented by number of patents and venture financing. Such expectations are quite feasible for all country groups including the "empty pocket" group and the 'Structural Funds dependent' countries that were less affected by crisis.
- Scenario 3 "Strengthening demand-side instruments/procurement" is likely to be associated with an increase in R&D employment and innovation performance via a generally positive direct effect of GBAORD on venture capital financing, and the indirect effects associated with the mutual interplay of BERD and GBAORD regarding R&D personnel and VC funding. The direct effect of an increase in BERD on patenting activities is expected to be positive as well. We can expect to observe such dynamics in different types of countries.

Summarising the above findings allows us to conclude that, given the information available at this moment about the dynamics of different RDI input and output indicators, it is possible to make a preliminary prospective analysis of future dynamics and possible effects of policy related changes. In general, the analysis shows that the policy shifts aiming at stimulating RDI activities in Member States are likely to be associated with an increase in RDI output. The extent of such an effect and the actual type of RDI output (both patenting and VC or one of them) can differ from country to country.

As it has been mentioned in the discussion above, the results of this prospective analysis are formulated under several conceptual (existence of a common trend driving RDI performance in Member States) and modelling (existence of a single equation cointegrating relationship) assumptions. The main requirement for a more precise and reliable prospective assessment of the policy effects on the main RDI performance indicators is the availability of longer time series with higher than annual frequencies, which makes it worthwhile to revisit these questions in the future.

6. Comparative case studies

The following case studies put specific group of countries under scrutiny that share common historical paths or similar framework conditions – even if their individual cases remain unique given the differences in size or economic structure.

The objective of these comparative case studies is to translate the results of the above overall analysis into more specific conclusions, and to derive implications for future research and innovation policies for specific country groups.

The groups have been selected based on key policy issues that they represent. Given the limitations for the breadth of this study, two country groups have been selected: the Czech Republic, Hungary and Poland, which are characterised by an innovation policy largely financed by the Structural Funds. The other group, Greece, Portugal and Spain, are countries that have been heavily affected by the crisis and are expected to struggle in terms of public budgets thereby limiting the room for research and innovation in the future as well.

The descriptive analysis is based on the Erawatch and TrendChart reports 2009-2012, on interviews with experts in the field and desk research.

6.1. Greece, Portugal, Spain – innovation in countries seriously hit by the crisis

Research and innovation performance

The financial crisis in 2008 had a profound effect on both general and knowledge intensive activities in Greece, Spain and Portugal as suggested by a set of indicators reflecting general economic activities as well as indicators in the knowledge intensive sector.

After the crisis hit, from 2008 onwards, R&D inputs (BERD, GBAORD and R&D employment) in Greece, Portugal and Spain have steadily decreased. Business expenditures on R&D (BERD) have been decreasing and GBAORD shows a similar pattern. R&D output (patents) also shows a negative trend in all three countries. Moreover, Venture Capital Financing in Greece and Spain display a negative pattern while remaining stable in Portugal. The ease of access to capital in the three countries sharply decreases to a level of 2 or below.

Table 13: RDI performance overview after the crisis

Country	RDI indicators patterns 200x-2013 period (where x represents the year of the crisis hit)						
	BERD	HERD	GBAORD	R&D Employment	Patents	Venture capital	Ease of access to loans
Greece			↓	↓	↓	↓	↓
Spain	↓	↑	↓	↓	↓	↓	↓
Portugal	→	↑	→	→	↓	→	↓

Before the crisis – from 2005 until 2008 – R&D inputs (BERD and GBAORD, HERD and R&D employment) in Greece, Spain and Portugal had followed a similar increasing pattern except for the R&D employment in Greece, which had remained at a constant level. The overall positive evolution in GBAORD before the crisis had been

accompanied by other government expenditures such as increased expenditures for environment protection, public order, tertiary education and transport. R&D outputs (Patents) in Spain had increased in the pre-crisis period, whereas the R&D output had remained constant for Greece and Portugal. Venture Capital financing in the pre-crisis period had shown a positive pattern in all three countries. This had been a general observation for other EU countries too. The ease of access to loans had already shown a decreasing trend before the crisis (in Spain it had appeared to be stable in the period before the crisis). Overall, the indicator 'ease of access to loans' between 2006 and 2013 had not shown a positive pattern before or after the crisis for the three countries.

Table 14: RDI performance overview before the crisis

Country	RDI indicators patterns 2005 - 200x (where x represents the year of the crisis hit)						
	BERD	HERD	GBAORD	R&D Employment	Patents	Venture capital	Ease of access to loans
Greece	↑	↑	↑	→	→	↑	↓
Spain	↑	↑	↑	↑	↑	↑	→
Portugal	↑	↑	↑	↑	→	↑	↓

Review of RDI policy trends

Beyond what is commonly understood as a 'southern European mentality', Greece, Portugal and Spain have experienced the crisis and responded to it in a different way. In reviewing RDI policy trends we emphasise commonalities and notable differences in the choices the three countries made particularly during the period of the crisis. The underlying reasons having led to the crisis, structural differences of their economic and industrial fabric and research and innovation systems while not the focus of this study are necessary in our understanding of the country level context. We briefly touch upon those aspects in the descriptions below to complement and support our reflections, namely prospective trends.

The innovation policy mix

The strategies and setting of policy priorities during the crisis period do not appear to result from a recession driven perspective, rather an attempt to address weaknesses of the research and innovation systems as understood at the times of programming and design of priorities. Moreover, there has been a very slow evolution in the national innovation policy mixes of the three Southern countries between the pre-crisis period (2004-2008) and post-crisis period (2009-2012) (Izsak, Markianidou and Radosevic, 2013).

In Greece, there had been an effort to balance research funding commitments with those promoting exploitation of research results and the transition to a knowledge driven economy before the sovereign debt crisis. Support to research infrastructures has been minimised for two reasons: scientific excellence (addressed only the research centres) and sustainable long term cooperation with business firms of any origin. Research projects were mainly supported either in the business sector or in consortia between firms and public organisations – international cooperation was encouraged in both cases. The notable focus on cooperation has been present during earlier programming periods since the year 2000. At the same time entrepreneurship was at the core of entirely new actions that spawned spin-off companies, private incubators and venture capital structures. To sustain the creation and growth of innovative enterprises PRAXE A and B were providing seed capital (A) and investment for the setting up of the spin-off (B).

The Spanish government has been taking action to tackle one of the main challenges of the research and innovation system, notably 'increasing business R&D expenditure'. The idea that Spanish fundamental research has traditionally been sufficiently funded publicly (with a deficient return in terms of innovative capacity and results for society) has gained importance. The design of the support measures gaining momentum from already before the crisis took its toll were those related to direct support of business R&D, including 'Public Venture Capital to New Technology-Based Firms' whose budgetary trend from 2006 to 2008 depicted an increase of 41% (EUR 22.4m in 2006 versus EUR 31.2m in 2008). The budget of measures supporting the 'Reindustrialisation and support to areas or sectors with difficulties' doubled in 2009 as compared to 2006 (EUR 222.8m in 2006 versus EUR 583m in 2009). Nevertheless the decrease in private R&D expenditures is especially sharp in particular basic R&D, which could undermine the long-term results and innovation and competitive level of the firms.

In Portugal the launch of the +E+I Programme in 2011 defined a new agenda for entrepreneurship. While it acknowledged the achievements of earlier efforts especially in the science and research fields, it aimed at emphasising entrepreneurship policy and particularly internationalisation. It therefore appears that entrepreneurship policy has gained momentum compared to R&D policy. This shift may be considered as the main change in the recent past although in terms of policy support measures there have been no major changes and the policy mix has remained largely unchanged. The increased concern with export (and import-substitution) performance in the assignment of innovation incentives to firms has also been pursued. This shift has also been reflected in the renewal of the agreement with the Massachusetts Institute of Technology (signed in 2013), which emphasises innovation and entrepreneurship through the stimulation of cooperation between universities and industry, and has as its main objective the development of internationally tradable technologies. Moreover, SIFIDE, the tax incentive system for R&D – which has been maintained and will be likely be extended – and R&D Vouchers have been merged. Such extended construction aims to support SMEs in other fields, namely Entrepreneurship, Energy and Internationalisation. The design of the RIS 3 strategies is expected to be influential in the setting of priorities with the main criterion being the identification of competitive or strategic intelligent advantages.

Impact on innovation budget

The negative trend of R&D appropriations as measured by GBAORD varies significantly across the three southern countries with Greece being severely affected, Spain experiencing a negative trend since 2010 and Portugal since 2009. It is also worth noting that the absolute level of budgetary appropriations of Greece and Portugal – two countries with comparable population – is strikingly different, with Portugal investing double or even triple as much during the 2010-2012 trend compared to Greece.

Table 15: Total R&D appropriations (€ Millions)

Country	2008	2009	2010	2011	2012	Growth 2008-most recent
Greece	940	751	596	573	581	-38%
Spain	8 414	8 700	8 308	7 252	na	-14%
Portugal	1 571	1 749	1 768	1 754	1 555	-1% (since 2009 -11%)

Source: Eurostat

In Greece budgetary cuts have been substantial though limited to institutional funding. Due to higher interest payments on debt and cuts imposed in public expenditure by the bailout agreement with the TROIKA - including salaries and operational costs – the government has fewer funds available to invest in areas that are necessary to

maintain future growth, such as in innovation, research and education, or the upkeep of infrastructure. From an operational point of view obtaining EU support has been obstructed by the inability of businesses to present the requested collaterals by banks, which ultimately hampers their ability to request funding to support their R&D and innovation activities.

Until 2010 Spain's innovation was seen as a main driver for the future competitiveness and a way to overcome the crisis. Although the Spanish government had reduced its public expenditures drastically, the budgets of R&D and innovation had decreased less than the average government expenditures. But further cuts thereafter finally impacted GBAORD in 2011 despite the anti-crisis plan of the Spanish government (Plan E) of 2009 that included an amount of EUR 490m directly related to R&D and innovation. This is more than 16% of the total budget of Plan E. The State Fund for Employment and local sustainability with a budget of EUR 5bn did not include a specific budget for R&D, but innovation was considered as a priority and 5.3% of the funds were devoted to proposals related to economic development and/or innovation. More recent information shows that most of the R&D and innovation support measures have been directly or indirectly hit because the former R&D and Innovation National Plan that ended in 2011 was extended until 2012 with no specific extension of the budget. The new National Plan was published in 2013 while the call for proposals was published in the beginning of November, just 3 weeks before the deadline. The budget allocations per instrument are not yet known since the Working Programmes that used to be available have not been published since 2011.

In Portugal budgetary restrictions have not significantly harmed the delivery of R&D and innovation support, since the corresponding instruments are to a significant extent supported by EU funds. The negative trend observed from 2011 onwards coincides with the introduction of crisis-based measures impacting budgets of institutional funding. In fact it has also been noted that HEIs experience difficulties in sourcing the necessary funds for their contribution in R&D projects, which are co-funded by the EU and national funds. Operational difficulties are also observed with respect to loan-based funding and in particular with obtaining guarantees, thus limiting those businesses willing to invest in R&D and innovation in obtaining support.

Competitive versus institutional funding

Budgetary cuts of institutional funding have been particularly felt in all three countries. Analysts speak of actions undermining the entire public research system of those countries, especially in the cases of Spain and Greece. As a consequence further deterioration from a hiring freeze to positions at universities being lost or situations in which researchers work unpaid raises concern of the already increased brain drain experienced in Greece, Spain and Portugal.

In Greece the budget for R&D is more exposed to the undergoing severe cutting of public expenditures. The budget for competitive R&D projects has not changed much due to the almost exclusive use of European funds to support R&D and innovation activities. Some reductions as a result of the limited co-financing with national funds were recorded. Institutional funding however, such as general university funds and operational costs for Research Organisations and Universities, has since 2009 been further reduced due to the salary cuts for researchers and academics, the cutback of other operational costs, and the restructuring of the public research sector through mergers.

In Spain both competitive and institutional funding has been affected. With respect to institutional funding various national sources indicate that the cumulative cuts severely affected institutional funding in 2012 (decrease of about 40% since 2009), which triggered a number of reactions from various R&D stakeholders. Delays in launching the 2013 call for proposals is expected to result in a one year gap in funding

coverage. The dimension of the impacted budgets of competitive funding has not been quantified yet. Earlier, the funds related to the R&D and innovation policy instruments had increased in 2010 and 2011 by 21% and 29%, respectively. In fact the budget had gone up from EUR 3570 million in 2009 to EUR 5604 million in 2011. This meant that similarly as in the case of Greece, the cut in GBAORD had especially affected direct public R&D expenditures such as the block funding for Public Research Organisations and Universities or other direct R&D expenditures of the Ministries.

In the case of both Greece and Spain these developments of decreases of budgets for R&D and innovation are particularly worrying for the future of HEIs that carry out public R&D, which has also been the case in Portugal since 2011. In fact a double-digit decline of 11% was recorded in 2012 during, which for example the budget of the Foundation for Science and Technology (FCT) was reduced and, recently, in 2013, the council of rectors refused to participate in a meeting with the Ministry of Education and Science as a response to the 'violation' of university autonomy and lack of transparency and explanations on budgetary cuts.

Brain drain

In 2011 a total of 166,000 people emigrated from Greece, Portugal and Spain, which is more than double the increase since 2007 for Greece and Spain in particular (OECD, 2013). Statistics mapping the current situation in these countries by level of education are not readily available but earlier statistics framing this discussion show for example that Greece, Portugal and Spain rank in the top five countries with the highest per cent in migration in the EU due to the scarcity of jobs and that in particular researchers tend to be more mobile than researchers in for example Germany.

Table 16: Brain Drain

Emigration Indicators	Greece	Portugal	Spain
Outflows of nationals in 2011 index (index base year 2007=100)	236	125	224
Reason to migrate: No job found before migration (% of total migrants) (in 2008)	57%	33%	46%
International mobility of doctorate holders, by last destination, 2009 (% of national citizens with a doctorate having lived/stayed abroad in the past ten years) bearing in mind that e.g. DEU: 3.1%	N/A	EU27: 12.9% US: 3.8% Other: 2.6%	Total: 21.1%

In Greece brain drain amounts to between 8.5% and 10.5% of graduates and is increasing as a result of the current economic crisis (Nioras, 2011). The OECD notes that flows to Germany, UK, the Netherlands and Sweden increased sharply in 2012 by almost 70% for Germany and 40% for Sweden, for example. Compared to those who stay, emigrants tend to be more educated and younger (OECD, 2013).

In Spain while there is an upward trend of people emigrating and net migration is negative, the absolute numbers are small and are comprised of mainly foreign and recently naturalised Spanish citizens (OECD, 2013). No information is known on the educational level of these people. In Portugal emigration had been rising since mid-2000 and most recent figures point out that sharpest increases are recorded in the number of emigrants going to non-EU destinations (OECD, 2013). The economic growth in Brazil and Angola, both Portuguese-speaking countries and former colonies, possibly explain this trend.

Brain drain tendencies had been recognised in Greece, Portugal and Spain before the crisis hit. To reverse this trend typically support measures have aimed at creating attractive employment conditions for researchers to return especially in the case of

leading academics, researchers and innovators. For example, Spain introduced in 2005 a programme that grants partially the cost of researchers' contracts in Public Research Centres (or non-profit Private Centres) for a period of five years, extended in the call of September 2012 to up to seven years. In Greece several measures were launched over the previous programming period aiming at supporting researchers and retaining highly qualified personnel (see also Table 17). In terms of attracting leading academics a pilot project of Greek research chairs at research centres is currently in the design phase.

Table 17: Support measures to attract researchers

Country	Example of measures
Greece	• The measure 'Support of Postdoctoral Researchers' supports the outward and inward mobility of researchers with special emphasis given to young scientists. • The 'Heraclitus II' programme provides grants to researchers to conduct their PhD studies. In this way, the measure targets at increasing the quality and potential of research personnel in HEIs in order to reinforce the research activity in the higher education sector and also to raise the absorptive capacities for RTDI in the enterprises. • The measure 'Archimedes III' aims at strengthening the research capabilities and developing highly qualified human potential for research in technical HEIs (T.E.I.s) through the provision of funding for conducting research projects by the institutions' research teams.
Portugal	• The Investigator FCT – IF programme was launched in 2012 to facilitate the recruitment of highly qualified researchers to work in Portuguese research institutions, by celebrating employment contracts with FCT. This program predicts the recruitment of eighty FCT Investigators to be hired in 2012. Further calls are foreseen in the coming years (MORE 2 country fiches, 2012).
Spain	• 'Ramon y Cajal' Programme (RyC) postdoctoral senior grants. Measure launched to give response to the researchers community claims about the lack of job opportunities in the National Public Research System. The programme grants partially the cost of researchers' contracts in Public Research Centres (or non-profit Private Centres) for a period of five years, extended in the call of September 2012 to up to seven years. A commitment from Public/Private Research Institutions (RTO and Universities) in this initiative is required. • 'Juan de la Cierva' Programme. The main feature of this programme is the recruitment of postdoctoral researchers by public or private R&D centres on three-year contracts. The programme aims to increase the research capabilities of R&D groups and institutions in both the public and private sector by recruiting qualified researchers. The objective of this programme is to permit young postdoctoral researchers to integrate themselves in research activities of the Spanish R&D system. It is directed in particular at researchers who have recently been awarded their PhD (or are about to get it) and is designed to enable them to join research teams and continue developing their research skills.

However, pre-existing obstacles such as the low remuneration levels for researchers and limited career progression prospects compared to the offer in other Western and Northern European countries are difficult to address during a time of recession and budgetary constraints. Brain drain nonetheless also goes beyond researchers to include for example engineers, architects, health care workers etc. who given high unemployment rates search for jobs beyond own borders. Of particular interest to be further investigated in the future are views discussed namely in the literature concerned with developing countries on: 1) short and longer term benefits due to remittances; 2) returning migrants, and 3) incentives to get more education or maybe targeted education in fields of known high demand in other countries - like engineering with a high demand for human capital in a number of European countries (i.e. Belgium and Germany).

Absorption of funds

Insufficient absorption of RTDI funds may be caused by deficiencies and shortcomings in public administration and too low a number of concrete projects. Other reasons often identified beyond the crisis include co-financing capabilities, changes in governments and effects of national sectoral reforms (Deutsche Bank, 2012).

In the three Southern European countries the absorption of RTDI funds appears to have deteriorated in the period 2008-2012 as a result of the crisis. In 2011 the EU has reacted by temporarily increasing co-financing rates by 10 percentage points for those countries under financial difficulty. Greece and Portugal joined the mechanism directly and Spain in 2012. Most recent reports show that in 2013 there have been signs of improvement. The operational barriers of issuing guarantees from banks in order to obtain loan-based EU support for R&D and innovation activities but also the inability of businesses who have been eligible for direct EU funding to present the requested, by banks, collaterals has been an on-going issue for which no solution has yet been suggested.

In the case of Greece insufficient funding absorption had been identified before the crisis hit. During the crisis in Greece the severely reduced budget of the Public Investment Programme led to the limited absorption of the Structural Funds - almost the only available resource for funding development and RTDI projects. The steep reduction in the budget of the National Investment Programme as a result of the current economic crisis also reduced the absorption rate of the Structural Funds, as the National public co-financing could not be provided. To cope with this situation and increase the absorption rates of the Structural Funds the national contribution (matching funds) was considerably reduced in 2011, and at the same time the 2012 State Budget had projected an 11.8% increase in the Public Investment Programme. During the last quarter of 2013 Greece has significantly improved the absorption of Structural Funds.

In Spain the level of execution of the budget for 2009 was 81.6%. In other words, almost 19% of the anticipated budget was unused. This is a similar percentage to that of 2008. On the other hand there is some under-estimation of the policy budgets. The mentioned sources include only the national expenditures excluding the budgets of the regional R&D plans. Anecdotal evidence suggests that decreasing number of firms that carry out innovation created a situation that certain funds for innovation do not have enough applications. More recent information is not currently available.

In Portugal, despite the difficulties noted in the 2012 Strategic report, progress has been made positioning the country among those with the highest total absorption rates according to the latest reports of the EC. However, while the absorption of funds for R&D and innovation has improved it is not the main driver for this the noteworthy improvement – namely driven by non-R&D investments for example in the realm of industrial policy. Difficulties in absorbing funds may also occur as a result of the aforementioned difficulties of HEIs in sourcing the funds needed for them to participate in co-funded with EU and national projects, and the discouragement of companies in performing R&D and innovation activities – or postponing R&D and innovation activities, due to their inability to obtain or to pay for costly guarantees.

Form of funding

In Greece grants remain the predominant type of support for R&D and innovation. This goes against the notable shift in the form of funding towards subsidised loans, guarantees and tax incentives, introduced by the new Investment Law (3908/2011) in 2011, which has primarily been used for non R&D and innovation activities. In addition, another innovation of the new Investment Law, compared with the previous one, is the provision of higher ceilings in terms of subsidies, tax remits and capital depreciation for innovative ventures. The rationale for this significant change is rooted mainly on the limited impact of the generous subsidies provided by previous

investment laws. In funding R&D and innovation, while there has been an attempt to increase the role of new financial instruments (i.e. Jeremie, Support of innovation through venture capital – predominantly supporting non R&D and innovation investments like for example modernisation investments, the establishment of the Entrepreneurship Fund) the heavy losses suffered by banks as a result of the sovereign debt restructuring pose limitations in the support of R&D and innovation through loans. Similarly, the effort to establish tax incentives for R&D and innovation was rejected by Troika (EC, IMF, ECB) due to its negative effect on public revenues from taxes. Prior experience with R&D tax incentives resulting in high costs and hence loss of revenue of national sources also contributed to this decision especially considering the persisting impact of the recession in Greece. Other forms of funding like innovation vouchers have in contrast to Ireland and the Netherlands not been successful in Greece. The low R&D capacity and links between academia and industry may partially explain this outcome.

In Spain until 2012 grants had been present in 83% of support measures but only 75% of the total amount of the RDI project can be funded by grants. Subsidised loans, including interest allowances, are the second form of funding most implemented due to the lowest interest rates offered to enterprises. Although tax incentives (including reduction of social charges) is not a very extended measure, the government wanted to emphasize it, extending fiscal incentives beyond the year 2001 which was the initial deadline. Venture capital (including subordinated loans), guarantees and no direct funding provided have been of a lower proportion compared to the previous measures. Both tax incentives and grants received by firms have financed 20% of all the business expenditures in R&D. The majority of the support though comes from grants. This kind of support financed 12-14% of business expenditures in R&D in 2004-2006 while in the last few years this percentage increased to 17-18%. The tax incentives had financed around 5-6% of business expenditures in R&D in the period 2002-2006. The expected tax deductions for 2008-2009 had been 4-5% (no information on the actual percentages is available). This is not the result of a less generous support mechanism but could be an effect of the economic crisis.

In Portugal R&D and innovation funding is currently dominated by grants but the government has expressed its intention to shift towards loans. The only relevant tax incentive is SIFIDE, an R&D tax credit that has been viewed as a success story and will be continued in the future. It is interesting to remark that in spite of the financial difficulties, the level of incentives granted under SIFIDE for fiscal year 2011 was higher than for 2010, including a credit for the recruitment of high-skilled staff. The rather low awareness of this scheme by businesses and their difficulties in understanding the eligible activities (especially for SMEs) are aspects to be improved in the future. Finally, an increased focus has been put on venture capital policy. There has been a restructuring of public venture capital organisations, with the creation of Portugal Ventures, the new all-encompassing public venture capital organisation.

Thematic versus generic orientation

Traditionally funding in Greece, Portugal and Spain has been non-thematic. It is however expected that RIS 3 strategies regarding technological and sectoral specialisation under development for the programming period 2014-2010 will have an influential role.

In Greece the bulk of funding and most measures have been of generic orientation. Least attention is given, both in terms of funding and number of measures, to sectoral policies. The only differentiation in the focus of measures is the provision of funding for R&D towards sectors and technologies deemed as national priorities. Approximately (in terms of budget after 2009) 6% of the planned expenditure is directed towards thematic (e.g. ICT) or sectoral (energy) measures. RIS 3 strategies

point towards a shift towards more sectoral focus with hence open funding schemes with sectoral priorities, mainly in the areas of renewable energies and green economy, but also in traditional sectors that need urgent technological modernisation.

Traditionally in Spain more efforts have been dedicated to the food, agriculture and fisheries sector, followed by biotechnology and transport areas. There are other sectors - information communication technology (ICT), health, energy, environment, nanosciences and nanotechnologies etc., for which support measures have recently been more relevant. In the new Spanish RDI National Plan there is a clear alignment with the Horizon 2020 Societal Challenges and Key Enabling Technologies (KET) approach. In this sense the mandatory requirement to define a Regional Innovation Strategy (RIS3) at Autonomous Communities Level has forced a Strategic reflexion that includes in many cases as part of the Smart Specialisation exercise to fit the Key Enabling Technologies into the traditionally strong sectors. Hence while traditional sectors remain key at certain regional areas, the National Plan is no longer structured around them.

In Portugal most funding does not have a thematic or sectoral focus. The bulk of funding is therefore assigned to projects on the basis of their general eligibility and merits, and not from a thematic or sectoral perspective. Exceptions exist, like the case of the collective efficiency strategies (particularly competitiveness and technology poles and other clusters), where the clustering theme is key. Another example concerns the financial innovation theme, which accounted for around 9% of total approved funds for 2010. In the field of support to scientific infrastructures, a significant share was geared towards the Iberian International Nanotechnology Laboratory (INL), a joint Luso-Spanish endeavour, focused on nano-sciences and nano-technologies. Due to the economic and industrial structure of the country – showing a high sectoral diversification, the horizontal nature of policy programmes will most probably be continued with an expected increase of thematic calls following the recommendation of the RIS3 strategy.

Emphasis on ICT

In Greece an important effort is made for the dissemination of ICT throughout the economy, the civil service and households as an instrument for increasing productivity. The penetration of broadband technologies in recent years seems to be a success story.

In Spain, one of the support measures with substantial budgetary allocations is the Avanza Plan (EUR 1.72b in the period 2009-2010), an initiative of the government for the development of the Information Society that has been viewed as an essential element to the economic recovery. Since 2005, when the programme started, high budgets (EUR 5.07b in the period 2005-2008) had always been allocated due to the importance of the ICT sector in Spain.

In Portugal effort is put on the development of technological infrastructures, namely investments in new generation ICT broadband, which is expected to contribute to preparing the country for the future and improving its attractiveness. However, taking into account that most investments will be carried out by telecom operators, it is important to ensure that such investments would not be used as an excuse to keep Internet access prices among the highest in the EU.

Key observations

In summary, it has been observed that the crisis has not caused shifts in policy priorities but has negatively impacted budgets of namely institutional funding (the case of Greece and Spain not Portugal). The latter development poses risks on the short to even longer term capacity of those countries to innovate in light of increasing

emigration numbers and brain drain effects. The former observation regarding the stability of policy priorities can be explained by the longer term programming periods during which priorities are set and hence major changes do not occur (in this case the 2007-2012 Structural Funds period).

The strategies and shifts in emphasis of policy priorities during the crisis period do not appear to result from a recession driven perspective rather an attempt to address weaknesses of the research and innovation systems as understood at the times of programming and design of priorities. From an exclusive R&D and innovation budgeting viewpoint countries' strategies vary. The emphasis on collaboration, has been a policy priority in Greece since the year 2000, a trend we have observed in Western (i.e. Germany) or Northern (Finland and Sweden) European countries with notably different profiles of innovation capacity to Greece. Portugal on the other hand has been focusing on R&D plus boosted support to Business R&D and Innovation, and Spain has been more oriented towards Business R&D and Innovation.

Realising the deterioration of access to finance for businesses combined with shrinking public budgets, alternative forms of funding like loans, tax incentives, venture capital, innovation vouchers have been put forward to encourage business R&D activity. Yet a great deal of public support has during the last five years been intended for general and industrial investment support not necessarily R&D and innovation support.

While an exhaustive analysis of the research and innovation system of those countries has not been the objective of this sub-section we take stock of the descriptive analysis of the recent past and current situation of R&D and innovation activities in Greece, Spain and Portugal as described above and reflect on recommendations for the future. The following discussion points are raised:

- With the banking sector having been hit hard and in the process of restructuring the possibility of shifting towards more loan-based forms of funding may not be immediately realisable. A closer cooperation with the local banks would seem to be necessary to address operational barriers and align objectives. Tax incentives on the other hand must be dealt with caution considering their negative effect on public revenues from taxes. A design accounting for monitoring expenses, assuring R&D and innovation expenditures are only included - thus most likely limiting the eligible expenses would be necessary. There is also a need to support SMEs in understanding eligibility criteria through for example intermediaries (i.e. specialised consultants).
- Setting policy priorities to address a country's R&D and innovation 'needs' could be primarily directed by a thorough knowledge of the economic and industrial structure of the country and not EU or leading innovators trends as classified by the Innovation Union Scoreboard. For example the aggregate impact of the policy mix and in particular the leading policy priority of academia - industry cooperation in Greece, though empirical evidence is scarce is perceived to have been limited due to primarily cultural barriers at HEIs and the limited R&D oriented businesses. Moreover given the predominant presence of SMEs and low and medium technology businesses with limited to no R&D expenditures, to achieve impact on a greater scale non- technological innovation to increase productivity and generally modernize businesses to improve efficiency and effectiveness may be a prerequisite.
- Prior experience shows that measures designed on the national level when applied on the regional level require regional adaptation if they are to contribute in boosting business R&D and innovation. The design hence of the RIS 3 strategies, which is expected to be influential in the setting of priorities, would benefit the most by the knowledge of what has not worked in the past and what have been the mistakes. For example support measures of R&D

vouchers or complex programmes in regions were almost no R&D oriented businesses exist are destined to fail. Moreover:

- a shift towards more thematic support measures designed to support sectors where regions have competitive advantages or the use of intermediaries who have a sound understanding of the financial needs of entrepreneurs and potential projects that could be developed (Komninos et al., 2013) are examples of policy design approaches suggested by experts.
- the persisting regional gaps and opportunity inequalities point towards the need for knowledge links supported by an understanding that capabilities do not have geographical regional borders.

- Halting further brain drain from occurring is a particular challenge given both the deterioration of working conditions due to the crisis and limited financing prospects from national funds in the near future but also the competitive remuneration packages of other intra and extra European countries. To attract and retain leading researchers financing alternatives would need to be sought internationally making also good use of existing scientific networks and strategic participation in Framework Programmes. As brain drain is difficult to constrain and although it has been a highly discussed topic but not high in the action list of governments it is important to specifically address solutions for retaining links with outstanding researchers and highly qualified professionals who are further developing their skills abroad.

6.2. Czech Republic, Hungary, Poland – and the 'Structural Funds' driven Central-Eastern European country group

Research and innovation performance

Indicators on general economic activities indicate a profound effect of the financial crisis in 2008 in Czech Republic, Hungary and Poland. Concerning the knowledge intensive activities, an effect is only observed for Czech Republic. It is possible that this effect is not observed in Hungary and Poland because the knowledge intensive activities are rather limited compared to EU averages. The 2001 internet bust caused a slowdown in the general economic indicators only in the case of Poland. No effects were observed for Czech Republic and Hungary. When we look at the research and innovation performance related indicators, we find that BERD and Patent figures of Hungary, Czech Republic and Poland are following the same increasing pattern before the crisis. RDI performance indicators in Czech Republic display a positive evolution, except for the Venture Capital, which appeared to be stable. Hungary has, besides an increase in BERD and Patents, also an increase in R&D employment in the period before the crisis. Venture capital as well as ease of access to loans remained at a similar level. GBAORD though already showed a decreasing trend before the crisis. Poland, just like Czech Republic, had a positive evolution of GBAORD before the financial crisis. In Poland, R&D employment appeared to be stagnating in that period while the ease of access to loans already showed a negative pattern.

Table 18: RDI performance overview before the crisis

	RDI indicators patterns 2005- 200x (where x represents the year of the crisis hit)

Country	BERD	GBAORD	R&D Employment	Patents	Venture Capital	Ease of access to loans
Czech Republic	↑	↑	↑	↑	→	↑
Hungary	↑	↓	↑	↑	→	→
Poland	↑	↑	→	↑	↑	↓

After the financial crisis, patent figures as well as the ease of access to loans switched from a positive towards a negative evolution. For Hungary, patents and the ease of access to loans also displayed a negative pattern. For Poland, the patent figures and the venture capital are stagnating after the financial crisis. Contrary to most evolutions, R&D employment increased after the financial crisis in Poland. Both BERD and R&D employment show a positive trend after the financial crisis for the three countries. Venture Capital availability is stable after the financial crisis and the ease of access to loans is overall decreasing. Table 18 and 19 provide an overall overview of the patterns of RDI performance indicators before and after the crisis for Czech Republic, Hungary and Poland.

Table 19: RDI performance overview after the crisis

	RDI indicators patterns 200x-2013 period (where x represents the year of the crisis hit)					
Country	**BERD**	**GBAORD**	**R&D Employment**	Patents	Venture Capital	Ease of access to loans
Czech Republic	↑	↑	↑	↓	→	↓
Hungary	↑	↓	↑	↓	→	↓
Poland	↑	↑	↑	→	→	↓

Research and innovation policy

The three Visegrad countries, the Czech Republic, Hungary, Poland share a similar historical past, transformed themselves into a free market economy since the 1990s and joined the European Union in 2004. Although their economic structure and size are quite different: Poland being the largest economy with both strong industries and large agricultural basis, Czech Republic highly industrialised and Hungary with a more services-oriented structure, their innovation systems followed a parallel development path.

They departed from a policy that had been oriented towards institutional research and developed a set of innovation policy measures that support business innovation, research-industry linkages and knowledge transfer mechanisms. In the early years, the innovation policy focused on strengthening research infrastructure, building up the institutional background and intermediaries such as incubators and innovation agencies. Business support was centred on technological upgrading and stimulating the diffusion of existing technologies into the economy rather than fostering brand-new innovations. Other commonality is that since 2004 their R&I policies have been largely financed by the Structural Funds and it is also expected to remain important in the upcoming period.

The innovation policy mix

Since 2004 all three countries introduced several initiatives to foster linkages between public and private actors of the innovation systems and to stimulate technology transfer. Several measures also exist to support industrial R&D. They have also experimented with new innovation policy instruments such as cluster policies,

innovation vouchers, and establishing competence centres. Table 20 summarises the most important features of the policy mixes.

Table 20: Policy mix

Country	Competitive vs institutional funding	Public R&D/BERD (2011)	Industry-science collaboration	Grants vs loans	Tax incentives	State backed venture capital
Czech R	48%-52% competitive funding increasing	39,1%-60,3% BERD's share increasing	6,86%	90% grants	Yes	No (piloting)
Hungary	39%-61% stable	35,9%-62,4% BERD's share increasing	1,72%	70% grants	Yes, changed in 2010	Yes
Poland	67%-33% competitive funding increasing	69,63%-30,13% BERD's share increasing	7,12%	90% grants	Yes, but not relevant take-up	Yes

Source: Eurostat, analysis of TrendChart inventory funding figures
Note: The percentage of grants vs. loans is an estimate based on the TrendChart inventory and exact figures could not be calculated given the difficulty to separate the amount of loans for innovation projects and loans for general business development projects.

Czech Republic and Hungary have developed a similar policy mix in terms of the share of competitive versus institutional funding, share of public and business R&D and their orientation towards grants (although Hungary relies more on loans than grants compared to CZ or Poland). Tax incentives played a more important role in the Hungarian R&D system although the Czech Republic also introduced it since 2005. The Czech R&D tax incentive has been extended to deduct research expenditures purchased from research organisations in 2013. The practical implementation of tax incentives faced, however, administrative problems both in Hungary and the Czech Republic. As long as Hungary and the Czech Republic allocated more funding in the overall policy mix to business research and innovation, Poland focused more on the public research system and higher education institution.

Poland seems to be different in terms of their research being much more financed by the public sector and through competitive funding. Both Poland and Hungary launched measures to stimulate venture capital but to a limited extent. The Czech Republic is one of the countries with the least developed venture capital market and has just recently piloted state-backed measures.

The crisis did not change the innovation policy mix of these countries and based on the analysis of the last policy documents and working papers, they are not expected to change substantially in the future either. Nevertheless, some trends have indeed accelerated that might bring some slight shifts such as the quest for more loan-based funding, venture capital measures, further strengthening of science and industry linkages and some pilot actions to use innovative public procurement to stimulate the demand side of innovation.

Both in the Czech Republic and Poland new measures have been introduced recently that aim at strengthening support between industry and public research. In the Czech Republic and Hungary new policy initiatives strengthened business innovation and start-up support with the objective to helping enterprises to overcome the limited availability of external funding. All three countries announced plans to establish or strengthen loan-based instruments and public seed fund to boost the access to venture capital.

Despite of these changes, the overall framework for research and innovation policy has not changed and if there won't be bolder actions taken 'modus operandi' scenario in the upcoming period is more likely.

Impact of the crisis on public R&I funding patterns

Public funding to research and innovation has been increasing in the Czech Republic and Poland, but it has decreased in Hungary that has been hit harder by the sovereign debt crisis. It is to remark that as long as Poland is much larger country both in terms of population and economic weight than the Czech Republic, its spending on R&I/capita is much less. The low level of Hungarian GBAORD figures might also raise concerns.

Table 21: Total R&D appropriations (€ Millions)

Country	2008	2009	2010	2011	2012	Growth 2008-most recent
Czech Republic	821,357	870,254	893,93	1.048,315	1.058,479	28% (growth)
Hungary	453,452	426,559	349,287	296,173	:	-25% (decrease)
Poland	1.099,115	1.051,668	1,891.481	1,891.481	:	72% (growth)

These trends also reflect that research and innovation public budgets have been protected as disbursements through the Structural Funds are ring-fenced and will also provide stability in the future. The drop in the Hungarian funding figures shows that the government has been busier with the stabilisation of public financing and macro-economic measures and turned to general business and SME support measures rather than on innovation specifically. On the other hand, research and innovation (although claimed important) are not on the list of most important policies in any of these countries.

Innovation measures that worked in the times of the crisis

Measures financed through the Structural Funds meant stability for innovation projects. In Poland the 'Goal-oriented innovation projects' were evaluated positively and the number of application and supported projects kept being high even in the period 2009-2012. In the Czech Republic the 'Innovation', 'Potential' and 'Progress' sub-measures of the Enterprise and Innovation Programme have been instrumental to foster business innovation.

Interestingly, these countries did not encounter any significant drop in project applications due the crisis and the absorption capacity of the funds has stayed good. On the other hand the evaluation reports reflect problems in terms of the project quality and meeting the set of selection criteria.

The mid-term evaluation of the Czech Republic Enterprise and Innovation OP carried out in 2011 concluded that the programme funding raised the competitiveness of the supported businesses and enabled an increase of the production capacity, higher production efficiency, increase in the number of customers.

Framework conditions for an innovation-friendly business environment

Although the policy portfolio seems to be comprehensive, there are some important framework conditions that have been not yet managed to improve to the desirable

extent and might hamper innovation activities. This shortcoming has been become even more pertinent in the period of the crisis.

Legal frameworks that stimulate researchers to commercialise their research results are still not conducive to innovation. Although the system of technology transfer offices has been developed, there are not yet efficient incentives for researchers to think in terms of business development. Moreover there is not enough trust between academia and industry for joint innovative initiatives and so far several negative experiences have been also encountered.

A knowledge-based intellectual property market is one prerequisite that can stimulate innovation. In all three countries IPR is not yet exploited to the optimal extent. In Poland IPR is protected through the copyright act and the industrial property act, however, the regulations are still to be improved so that more motivation would exist to commercialise research results and new ideas. The Czech Republic made efforts to foster the utilisation of IPR protection through actions within the national research, development and innovation programme. In Hungary commitments have been made to support of IPR protection for Hungarian inventions abroad since 2006.

Cultural and historical barriers are still very much responsible for the less innovation-oriented environment. Although there have been several awareness raising initiatives implemented, innovation and entrepreneurship are still not sufficiently understood or coded in universities, research centres or students that enter the labour market the first time.

Institutional challenges

All three countries still face the challenge to improve the utilisation of public funds to support research and innovation and to further develop the innovation system so that it is more supportive to the formation of system linkages. Looking at the fact that in 2007-2013 all of them had a huge opportunity to develop their research and innovation systems through the high-level of funding arriving through the Structural Funds, the most recent performance indicators do not yet reflect that they managed to change to a gear of an innovative economy.

This has been discussed by several authors (Havas, 2011) who coined this as the 'Hungarian paradox' or 'Czech paradox' of showing a poor performance despite of a broad-set of R&I measures.

First of all the political background has a major impact on research and innovation policies. In the Czech Republic and Hungary the political instability in recent years had influenced policy initiatives negatively and hampered a consistent policy-making. In the Czech Republic there have been changes of ministers that make it difficult to implement innovation policies (Arnold, 2011).

There is still a lack of strategic intelligence in the ministries that could underpin a more evidence-based innovation policy-making. Much more has to be done to strengthen the evaluation culture of research and innovation programmes and to establish an appropriate feedback loop and policy learning based on the experiences encountered.

Road to smart specialisation

Poland implemented a National Foresight Programme in 2010 and in parallel it carried out a project called 'Technological Foresight of Industry – InSight 2030' (www.fortech2030.pl) in 2011. As a result, the proposed priorities for the Polish industry for the timeframe up to 2030 are concentrated around 35 competitive industrial specialties, aggregated into 10 research areas (MG, 2011). Nevertheless, these efforts did not reduce the uncertainty surrounding R&D priorities of the

government as the areas remained too broad. In Hungary the preparation of the regional smart specialisation strategies has started early 2013. The National Innovation Office is responsible for the coordination and carrying out the societal consultation process. Similarly to Hungary, in the Czech Republic R&I policy-making is centralised. The national smart specialisation strategy is being drafted in cooperation of the national and regional authorities.

An important threat in all of the three countries is that the selected specialisation areas are not fully based on a thorough analysis and serious debate, which identify real niche opportunities, but rather they follow broad topics, popular technological trends or the interest of a small group. It caused further problems that the multi-level coordination between the national and regional levels are weak and this can hamper the development of real 'place-based' strategies.

Summary of observations

Based on the above overview the following key observations can be made that will have an implications for future research and innovation policies:

- Understanding and addressing barriers and stimulating factors in the wider framework conditions for innovation would need bolder actions. Research and innovation policy-making cannot be done in isolation but needs real incentive mechanism for commercialisation of research results, diffusion of knowledge and business innovation that are linked to the broader business environment, to the legal framework, regulations, procurement practices and in sectoral policies (eg in environmental policy or health care).
- Good ideas will fail if the national innovation systems do not function properly. There have been some important actions taken in the previous policy cycle to establish innovation support intermediaries, technology transfer offices or incubators and science parks. As we have seen before, a lack of consistent and long-term policy-making process can hamper the impact and hence there is a need to build upon these established structures. This does not mean that there is no need for change and the quality of these delivery structures should be monitored and continuously improved. To this end, further developing the policy evaluation culture would clearly help. On the other hand, bridges are still missing between science and industry that should be further strengthened.
- All three countries rely to a large extent on Structural Funds financing of their innovation policy. There is a need for stocktaking what worked and what not in the previous period so that the utilisation of these funds become more optimal in the upcoming period. It should be also kept in mind that Structural Funds won't last forever and there is a need to be prepared for a phase out.
- Future success will largely depend on the viability of smart specialisation strategies and their implementation. There would be a need for a more serious reflection on what are the real niches and opportunities.
- Launching and piloting loan-based measures and state-backed venture capital funds is welcome, but these measures have to meet with a sufficient quality of projects and start-up ideas. This means that grant schemes, collaborative research programmes and innovation support measures will still keep their importance and cannot be neglected.

References

Archibugi, D., Filippetti, A. and M. Frenz (2013), "Economic crisis and innovation: Is destruction prevailing over accumulation?," Research Policy, Vol. 42, pp. 303-314.

Balaz V. (2011). INNO Policy TrendChart Mini country report on Slovakia.

Balaz V. (2012). Erawatch Report on Slovakia.

Belitz H et al (2013). Innovation Policy for SMEs Proves Successful. DIW Economic Bulletin 4. 2013.

Bérubé, C., Mohnen, P. (2007). Are Firms That Received R&D Subsidies More Innovative? UNU-MERIT working paper series. Available at: http://www.merit.unu.edu

Beylat J.L., and Tambourin P. (2013). L'innovation un enjeu majeur pour la France

BIS (2012). Early assessment of the UK Innovation Investment Fund. Report by: Centre for Enterprise and Economic Development Research (CEEDR) Middlesex University Business School Assisted by Sanders Thomas Ltd.

BIS (2011). Funding for EU Research and Innovation from 2014. A UK perspective.

Bogliacion F., Lucchese M. (2011). Access to finance for innovation: The role of venture capital and the stock market. IPTS Working Paper on Corporate R&D and innovation. No 5/2011.

Bloom, N., et al. (2002). Do R&D tax credits work? Evidence from a panel of countries 1979 - 1997. Journal of Public Economics, vol.85.

Bucar M. (2011). INNO Policy TrendChart Mini country report on Slovenia.

Centro para el Desarrollo Technologico Industrial (2010). Informe annual.

Corchuelo, M.B., Martínez-Ros, E. (2010). Tax Incentives and Direct Support for R&D: What do Firms us and why. Available at: http://www.ucm.es.pdf

Colombo, M.G., Grilli, L. (2005), Founders' human capital and the growth of New Technology-Based Firms: a competence-based view. Research Policy, 34, 795-816.

Crépon, B., Duguet, E. and J. Mairesse (1998). Research, innovation and productivity: an econometric analysis at the firm level, Economics of Innovation and New Technology, Vol. 7, pp. 115-158.

Cunningham P., Sveinsdottir T., Gok A. (2011). INNO Policy TrendChart Mini country report: UK.

Cunningham P., Sveinsdottir T. (2012). ERAWATCH Analytical country report 2012: United Kingdom.

Czamitzki D and Toivanen O. (2013). Innovation Policy and Economic Growth. Economic Papers 482, April 2013. European Commission.

Department for Business Innovation and Skills. (20xx). Available at: https://www.gov.uk/government

DIHK (2009). Innovation activities of german companies in the economic crisis. Association of German Chambers of Industry and Commerce. Authors: Dr. Volker Treier, Michael iecke and Anna Maria Heidenreich.

EVCA (2013). The middle market: Europe's real economy strongman. http://www.evca.eu/publications/PBEVCAB6.pdf

European Commission (2011). Innovation Union Competitiveness Report 2011.

European Commission (2013). Innovation Union Competitiveness Report 2013.

European Commission (2013). European Economic Forecast Spring 2013.

European University Association (2012). EUA's public funding observatory June 2012.

Falk, M. (2009). Evaluation of Government Funding in RTDI from a Systems Perspective in Austria. Report 4: Tax Incentive Schemes for R&D.

Falk, M. (2004). What drives Business R&D Intensity across OECD countries? WIFO Working Papers. Available at: http://www2.druid.dk

Federal Public Service Finance. Tax Incentives for R&D Activities. Available at: http://minfin.fgov.be/portail2/belinvest/downloads/en/publications/bro_r_and_d.pdf

Fernandez-Zubieta, A. (2012). ERAWATCH Country Reports 2012: Spain

Filippetti, A. and D. Archibugi (2011), "Innovation in times of crisis: National Systems of Innovation, structure, and demand," Research Policy, Vol. 40, pp. 179-192.

Finnish Industry Investment Ltd's interim review 01-06/2013. Industry Investment.

Geyer A. Tiefenthaler B. (2011). Programmevaluierung "Headquarter-Strategy". Endbericht an das Bundesministerium für Verkehr, Innovation und Technologie (BMVIT)Technopolis Group.

Greene, W. (2003), "Econometric Analysis", Prentice Hall, p. 658.

Griliches, Z. (1979). Issues in assessing the contribution of research and development to productivity growth, Bell Journal of Economics, Vol. 10, pp. 92-116.

Guellec, D. and B. van Pottelsberghe de la Potterie. (2000). The Impact of Public R&D Expenditure on Business R&D. OECD Science, Technology and Industry Working Papers, 2000/04, OECD Publishing. Available at: http://dx.doi.org/10.1787/670385851815

Hall, B. (2002). The Financing of Research and Development, Oxford Review of Economic Policy, Vol. 18, pp. 35-51.

Harris, R. and G. Judge (1998), Small sample testing for cointegration using the bootstrap approach, Economics Letters, Vol. 58, pp. 31–37.

Havas A. (2012). Country review: Hungary. INNO Policy TrendChart.

Havas A. (2011). A Hungarian paradox? Poor innovation performance inspite of a broad set of STI policy measures, Triple Helix 9 International Conference, Silicon Valley: Global Model or Unique Anomaly?, Stanford University, 11-14 July 2011.

Hebakova L. et al (2011). Mini country report – Czech Republic. INNO Policy TrendChart.

Heijs, J. (2011): Mini Country Report/SPAIN, Thematic Report 2011 under Specific Contract for the Integration of INNO Policy Trend Chart with ERAWATCH (2011-2012),

HM Revenue and Customs. (2013). Research and Development Tax credit Statistics. Available at: http://www.hmrc.gov.uk/statistics/research-tc/rd-introduction.pdf

IMAD. (2009). Development Report. Available at: http://www.umar.gov.si/en/o_umar/

IMAD. (2012). Development Report. Available at: http://www.umar.gov.si/en/o_umar/Ireland Department of Finance (2013). Review of Irelands's research and development (R&D) Tax credit 2013.

Johansen, S. (2002), "A Small Sample Correction for the Test of Cointegrating Rank in the Vector Autoregressive Model", Econometrica, Vol. 70, pp. 1929–1961.

McKenzie K. & Sershun, N.(2010). Taxation and R&D: An Investigation of the Push and Pull Effects. Canadian Public Policy. University of Toronto Press, vol. 36(3), pages 307-324

Kanerva, M., Hollanders, H. (2009). The Impact of the Economic Crisis on Innovation. INNO Metrics Thematic Paper. European Commission, DG Enterprise, Brussels.

Kohler, C., et al. (2013). The Impact and Effectiveness of Fiscal Incentives for R&D. Nesta Working Paper. Available at: http://www.nesta.org.uk/library/documents/wp12-01v2.pdf

Klitkou A. (2012). Country review: Denmark. INNO Policy TrendChart.

Kristapsons J., Draveniece A., Adamsone A. (2012). INNO Policy TrendChart. Mini country report: Latvia.

Mazars. (2010). Review of Global R&D tax incentives. Available at: http://www.google.be

Meyer-Ohlendorf et al. (2009). Progress towards sustainable development? ESDN Meeting, Prague June 2009. Background Paper.

Mohsen, D., Chittenden, F. (2006). Briefing - The role of tax incentives in capital investment and research and development expenditure decisions by small and medium enterprises. Institute of Chartered Accountants in England and Wales (ICAEW). Available at: http://www.icaew.com

Mostert B., Deuten J. (2012). Country review Netherlands. INNO Policy TrendChart.

Nemzetgazdasagi Miniszterium (2012). Befektetes a jovobe. Nemzeti Kutatas-fejlesztesi es Innovacios Strategia (2013-2020).

Paliokaite L. (2012). INNO Policy TrendChart Country review: Lithuania.

Parsons, M. (2011). Tax Policy – The role of Tax Incentives. Available at: http://www.pwc.

Pazour M., Valenta O. (2009). INNO Policy TrendChart – Innovation policy progress report – Czech Republic.

Popa, I., et al. (2012). Tax Incentives Schemes for R&D – A solution for the Romanian Economy. Review of general management, vol. 16(2). Available at: http://www.managementgeneral.ro/pdf/2_2012_5.pdf

Poti B. et Reale E. (2011). Mini country report – Italy. INNO Policy TrendChart

Ramlogan and Rigby (2012). Access to finance: Impacts of publicly supported venture capital and loan guarantees. Compedium of evidence on the effectiveness of innovation policy intervention. Manchester Institute of Innovation Research.

Reid A., Nightingale P. (Eds.) (2011) : The Role of Different Funding Models in Stimulating the Creation of Innovative New Companies. What is the most appropriate model for Europe? A report to the European Research Area Board. Study funded by the European Commission, Directorate-General Research.

OECD. (2013). Measuring R&D Tax Incentives, OECD Publishing. Available at: http://www.oecd.org/sti/rd-tax-incentives-provisions.pdf

OECD. (2013). Maximising the benefits of R&D tax incentives for innovation, OECD Publishing. Available at: http://www.oecd.org/sti/rd-tax-incentives-for-innovation.pdf

OECD. (2010). R&D Tax Incentives: rationale, design, evaluation, OECD Publishing. Available at: http://www.oecd.org/sti/ind/46352862.pdf

OECD (2012). Science, Technology and Industry Outlook.

OECD (2012). Mobility and migration in Europe. In OECD Economic Surveys: European Union 2012, OECD publishing.

OECD (2009), "Policy Responses to the Economic Crisis: Investing in Innovation for Long-Term Growth," OECD, Paris.

Schneider, C., Veugelers, R. (2010), On young highly innovative companies: why they matter and how (not) to policy support them. Industrial and Corporate Change, 19, 969-1007.

Schuch K. (2012). Country review Austria. INNO Policy TrendChart.

Tether and Stigliani (2012).

Tsipouri L., Reid A. (2009). European Innovation Progress Report 2009. INNO Policy TrendChart.

Tresor Economics. (2009). The economic impact of the 2008 research tax credit reform (Crédit d'Impôt Recherche). Available at: http://www.tresor.economie.gouv.fr/file/327006.

UK Department for Business Innovation and Skills. (2013). SME access to finance schemes: measures to support small and medium-sized enterprise growth. Available at: https://www.gov.uk/government

Van Pottelsberghe, B., et al. (2003). Evaluation of current fiscal incentives for business R&D in Belgium. Available at: http://solvay.ulb.ac.be

Vivarelli, M. (2013). Is Entrepreneurship Necessarily Good? Microeconomic Evidence from Developed and Developing Countries, Industrial and Corporate Change, forthcoming (DOI version).

World Economic Forum (2013). Global Competitiveness Report 2013-2014.Klaus Schwab.

Other Online Sources:

http://agefi.com/fileadmin/user_upload/documents/top_stories/EU_regimes_comparison_19_02_2013_Appendix_4_amended_05_03_2013.pdf

http://www.bdo.ie/services/tax/articles/rd-tax-credits-step-forward-not-leap

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/192618/bis-13-p176b-sme-access-to-finance-measures.pdf

http://www.koda.ee/en/services/taxation-of-corporations/incentives/

Appendix A Methodological notes

List of annual indicators used to assess RDI performance

In particular, the performance analysis makes use of the following individual indicators:

- Research and Development:
  - Total Business expenditures on R&D (BERD);
  - Total R&D personnel and researchers (FTE), in business enterprise sector;
  - Annual data on job-to-job mobility of Human Resources in Science and Technology;
  - Total employment in knowledge intensive activities;
- Science and Technology:
  - Total government expenditures on R&D (GBAORD);
  - GBAORD in the field of Environment;
  - GBAORD in the field of Energy;
  - GBAORD in the field of Industrial Production and Technology;
  - Number of EPO patent applications in High-tech sector;
  - Number of EPO patent applications in Biotechnology sector;
  - Number of EPO patent applications in Mitigation or Adaptation against Climate Change;
  - Number of EPO patent applications in Information and Communication Technology;
- Financial markets:
  - Volume of venture capital financing;
  - Index of access to loans from the Global Competitiveness Report.

Quarterly and monthly indicators used to assess the structural changes in economic dynamics:

- Macro-economic conditions:
  - Gross Domestic Product;
  - Gross Value Added (GVA) in Industry;
  - GVA in Public Sector;
  - Final consumption of households;
  - Total turnover in professional, scientific and technical services;
  - Total turnover in knowledge intensive and high-tech sectors;
  - GVA in Information and Communication technology;
  - Monthly production index in Manufacturing;
  - Monthly index of turnover in ICT;
  - Monthly index of turnover in Pharmaceuticals;
  - Monthly index of turnover in Professional, Scientific and Technical Services.

Box 1: Methodology of the structural break analysis

Testing for structural breaks[19]

In application to a regression model we say that a structural break has occurred if at least one of the regression's parameters (it can be intercept or one of the slopes) has changed at some date in the sample period.
The classical test for structural change is one introduced by Chow. This testing procedure splits the sample into two sub-periods, estimates the parameters for each sub-period, and then tests the equality of the two sets of parameters using a classic F statistic.

The basis equation for the estimation is a linear regression with a output performance indicator as a dependent variable and a vector of other relevant explanatory variables.

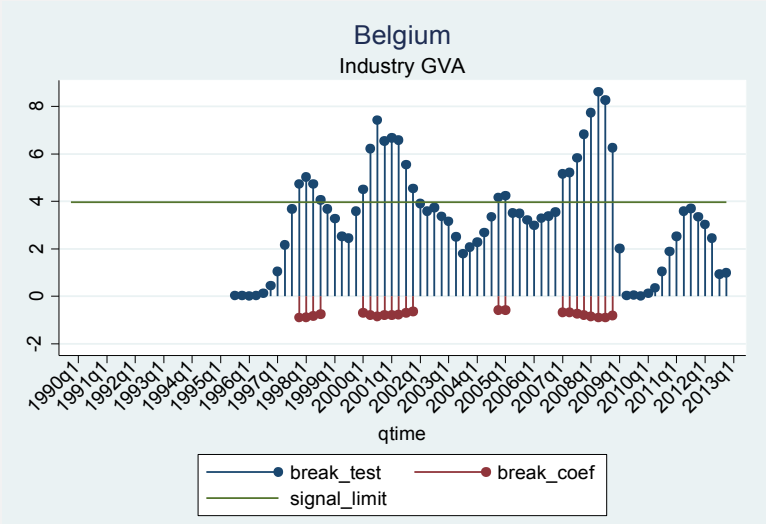
The analysis is carried out for a number of dependent variables, such as GDP evolution, industrial production, turnover in knowledge intensive activities, etc.

In the framework of the above relationship equation it is possible to identify structural breaks at two levels:

- the test for a structural change in terms of the time dynamics of the indicators (so called shift in means);
- the test for a policy related structural break in terms of the time dynamics and the slopes of the main economic explanatory variables. Such a setting allows us to see whether the shift had a more profound effect and led to changes in the main relationships between the output and the main explanatory variables.

To identify the possible moments of the structural change in the output indicators and the underlying relationships it is intended to calculate the corresponding statistical tests at every time moment during a given time period (for example every quarter during 2005-2011, see Hansen (2001)). These tests are then plotted in a single graph, which contains three information pieces:

- a plot of the statistical tests for structural break (blue);
- a horizontal line representing the 5% critical value for the test above which we can reject the hypothesis of no structural break;
- a plot of detected changes in the series mean in the points where the structural change test statistics exceeded the 5% critical value.



[19] Hansen, Bruce E. (2001). "The New Econometrics of Structural Change: Dating Breaks in U.S. Labour Productivity." Journal of Economic Perspectives, 15(4): 117-128.
Greene, W. (2003), "Econometric Analysis," 5th Ed., Prentice Hall, p. 119.

If for a given quarter that value of the structural break test reaches the level above the critical value, it means that there is a statistically significant signal that at this date a structural change in the time dynamics of the output variable has taken place.

Thus the main points of interest for us when interpreting the results are the points where the test statistic lies above or very close to the critical value threshold.

Appendix B List of R&I measures with an objective to stimulate business innovation introduced in the crisis period or linked to the crisis

Country	***Policy measure***	***Date of measure or additional stimulus***	***Budget €***
Austria	Austrian RTDI Initiative Intelligent Production	2011	14 m (2011)
	Research premium – tax incentive	2009	254.6m (2009) 328.8m (2010)
Belgium	The ARKimedes Fund- PMV (Participatie Maatschappij Vlaanderen) VINNOF PMV (Participatie Maatschappij Vlaanderen)	2009 2009	104.7 m (2010) 128.3 m (2011) VINNOF 20 m (2009)
Czech R.	Alpha Programme	2011	
Cyprus	Young entrepreneurship	2012	4 m
Denmark	Business Innovation Fund	2009	29,9 m (2010) 35 m (2011)
	Business Development Finance/Growth Funds		203 m (2009) 295 m (2010) 867 m (2011)
Estonia	Start-up and Development Grant	2011	4,7 m (2011)
	Technology investment support in industrial enterprise	2008	75,6 m (2008-2013)
Finland	Vigo Accelerator	2009	
	FoF Growth Fund and Growth-financing programme	2009 and 2013	1 000 m (2013-2017)
France	Strategic Investment Fund	2008	
	Research Tax Credit	2008 (reform) 2011 (refining conditions)	4 200 m (2008)
	Bank of Public Investments BPI France	2012	
Germany	ZIM (started in 2008, budget increased in 2009)	2009 2009 2011	320 m (2009) 389 m (2011)
	High-tech Start-up Fund (budget increase)	2011	272 m (2010) 563 m (2011)
Greece	New Innovative Entrepreneurship	2011	19 m (2011)
	Innovation Fund	2012	21 m (2012)
Hungary	RTD Umbrella		
Ireland	Innovation Fund Ireland	2010	125 m (2011-2014)
	Seed and Venture Capital Programme	2013	175 m (2013-2018)
Italy	National Fund for Innovation	2009	60 m
	New tax benefits	2009-2011	2 900 m (total)
	The Italian Investment Fund	2010	
	New bill for innovative start-ups, researchers and investors	2012	
Lithuania	High Technology Development Programme	2011	2,6 m (2011-2013)
	Controlling Fund	2008	268 m (2008-2013)
	Corporate profit tax incentive for R&D	2009	
Malta	ERDF Small Start-Up, International Competitiveness, E-Business, Research and Development, Innovation Actions (Innovation) and Innovation Actions	2010	11.4 m (2010) 11.4 m (2011)

	(Environment)		
Netherlands	Innovation Credit, Innovation Fund SMEs	2008	37 m (2009) 47 m (2010)
	WBSO R&D tax incentive (further broadened)	2009, 2012	RDA: 250 m (2012) WBSO: 864 m (2012)
	BMKB Scheme SME Loan Guarantee Scheme	2009	765 m (2010) 1000 m (2011)
Poland	Portugal Ventures	2012	
Portugal	FINOVA (access to finance)	2009	100 m (2009-total)
	SIFIDE (tax credit)	2010	
Romania	Tax exemption	2009	
Slovakia	Tax incentive	2009	20 m euro (2009-2012)
Slovenia	Credits for R&D investment expanded	2009	
Spain	FondICO Global Fund	2013	NA
	Start-up Co-investment Fund	2012	
Sweden	Business Incubation for Growth	2011	7,7 m (2011)
	Challenge driven Innovation	2011	
UK	Enterprise Finance Guarantee	2009	2 160 m (total)
	Innovation Investment Fund	2009	390 m (2009)
	Seed Enterprise Investment Scheme (tax incentive)	2012	174 m (2012)
	GrowthAccelerator	2012	60,4 m (2012)

Appendix C R&D Tax incentives

Table 22: R&D tax incentives - country level factsheet

Country	Since	Design	Limitations	Generosity rank	Preferential Treatment
Austria	1980s	▪ Tax credit design based on volume ▪ Includes treatment of excess claims	Ceilings and threshold dependent rates.	14	None
Belgium	1990	▪ Tax credit based on volume (includes treatment of excess gains). ▪ R&D tax allowances (carry forward) ▪ Accelerated depreciation of capital and social security/payroll withholding tax ▪ Tax incentives linked to corporate income arising from R&D or related activities	None	12	Enhanced tax credit/ allowances rates or more favourable terms for SMEs and Collaboration for the
Croatia	2007	▪ Tax credit design based on volume	Decrease of profit tax basis by up to 150% of the amount of costs covered by the state subsidy which may result in a decrease of the profit tax liability up the amount of the percentage of the costs covered by said state subsidy.	na	None
Czech Republic		▪ Tax allowances (carry forward)	Deduction from corporate income tax base 200% of the costs incurred in the realisation of R&D.	8	None
Denmark	2000	▪ Tax credit volume based (incl. treatment of excess claims), ▪ Accelerated depreciation of capital	Limitation of benefits through ceilings and threshold dependent rates: refund of negative tax relating to R&D activities (up to DKK 1.25 million).	16	None
Finland	2013	▪ R&D tax allowances (carry forward)	Limitation of benefits through ceilings and threshold dependent rates:	6	None

Country	Since	Design	Limitations	Generosity rank	Preferential Treatment
France	1983	▪ Tax credit volume based (treatment of excess gains, carry forward), ▪ Social security/payroll withholding tax ▪ Tax incentives linked to corporate income arising from R&D or related activities	Limitation of benefits through ceilings and threshold dependent rates (up to EUR 100 million)	2	Enhanced tax credit/ allowances rates or more favourable terms for SMEs and Collaboration: the tax credit rate is reduced from 30% to 5% for spending above EUR 100 million; the rate for the first tranche is raised by 50% for the first year in which firms join the mechanism and by 40% for the second year; Companies that benefit the JEI status (innovative SMEs) become eligible for a series of tax rebates including exemptions on corporate earnings taxes, local taxes and social charges associated with the employment of highly qualified personnel.
Greece	2009	▪ Tax allowances	Tax deduction up to 130% of the maximum allowable amount of aid	na	None
Hungary	1997	▪ Tax credit volume based ▪ R&D tax allowances ▪ Social security/payroll withholding tax ▪ Tax incentives linked to corporate income arising from R&D or related activities	Limitation of benefits through ceilings and threshold dependent rates	4	None
Ireland	2004	▪ Incremental tax incentive scheme (treatment of excess claims, carry-forward.	Limitation of benefits through ceilings and threshold dependent rates: Tax credit of 25% of the incremental R&D expenditure incurred in excess of the base year spend. The base year is 2003.	5	None

Country	Since	Design	Limitations	Generosity rank	Preferential Treatment
Italy	2007	▪ Tax credit incremental tax incentive scheme.	Limitation of benefits through ceilings and threshold dependent rates: 10% on volume;	na	40% (formerly 15%) if carried out with universities or public research organisations. The increase from 15% to 40% has the objective to promote closer networking between the business and science communities and it is expected to have an important impact.
Malta	2001	▪ R&D tax allowances	The allowable deduction is 200% of the R&D expenditure incurred	na	Additional incentives are provisioned for SMEs (e.g. related to industrial property costs: 70% for industrial research projects and 45% for experimental development projects; Collaborative R&D is also explicitly incentivised
Netherlands	1994	▪ R&D tax allowances (carry forward) ▪ social security/payroll withholding tax ▪ tax incentives linked to corporate income arising from R&D or related activities, no expenditure based R&D tax incentives	Social security/payroll withholding tax: with limitation of benefits through ceilings and threshold dependent rates: R&D wage tax credit amounts to 50%, provided that the total R&D wages do not exceed EUR 220,000 beyond that amount an 18% wage tax credit applies for the remainder.	7	Social security/payroll withholding tax: Enhanced tax credit/allowances rates or more favourable terms for SMEs: For starting companies, this wage tax credit is even increased to 64% (from 50%).
Poland	2006	▪ Accelerated depreciation of capital	No more than 50% of expenditures relating to the acquisition of new technologies.	15	Additional incentives are provisioned for private entities/ R&D Centres that can apply for the status of R&D Centre.

Country	Since	Design	Limitations	Generosity rank	Preferential Treatment
Portugal	1997	▪ Tax credit Incremental tax incentive scheme (carry-forward)	Limitation of benefits through ceilings and threshold dependent rates: 82.5% of total expenses on R&D; ceiling of EUR 1.5 million.	1	Tax credit/allowances rates or more favourable terms for SMEs.
Romania	2008	▪ Tax credit volume based ▪ Accelerated depreciation of capital	Limitation of benefits through ceilings and threshold dependent rates: Supplementary 20% deduction in addition to the normal deduction obtained via (amortisation of) R&D expenses was introduced	na	None
Slovenia	2006	▪ Tax allowances (carry forward)	The level of tax subsidy has been increased in 2010 from 120% of allowed deduction of R&D expenses from corporate income tax to 140% of R&D investment.	11	Regional differential treatment:additional 10% if the investment was made in the regions up to 15% under the average development level and by 20% for the R&D investments in regions where the development gap is more than 15%.
Spain	1995	▪ Tax credit incremental tax incentive scheme (carry forward) ▪ Tax incentives linked to corporate income arising from R&D or related activities	Limitation of benefits through ceilings and threshold dependent rates: up to a 40% reduction in social security taxes of R&D staff working for firm; 12% deduction for innovation.	3	None

Country	Since	Design	Limitations	Generosity rank	Preferential Treatment
United Kingdom	2001	▪ R&D tax allowances (treatment if excess claims: refund, carry forward) ▪ Accelerated depreciation of capital, tax incentives linked to corporate income arising from R&D or related activities.	Limitation of benefits through ceilings and threshold dependent rates: 225% rate of relief for the SME scheme. There's an upper limit of EUR 7.5 million on the total amount of aid you can receive on any one R&D project; 130% for Large company scheme - if there is an allowable trading loss for the period, this can be increased by 30% of the qualifying R&D costs.	9	hanced tax credit/allowances rates or more favourable terms for SMEs;

Source: a mix of publicly available sources was used (TC, 2012; TC, 2011; OECD, 2006; OECD, 2012; L'AGEFI, 2013, Deloitte, 2012)