

COEURE workshop on “R&D, innovation and growth”

Université libre de Bruxelles, June 23, 2015

Final report

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Final programme

8:00-8:30 WELCOME COFFEE

8:30-8:40 Welcome and Goal of the day **Estelle Cantillon (ULB) and Marianne Paasi (scientific officer of COEURE, DG RTD)**

8:40-11:00 **Session 1: What have we learned? What do we still need to know? Setting the stage (chair: Ramon Marimon)**

Brief presentation of survey by Prof. Philippe Aghion, discussion and complementary perspectives on the research frontier in R&D, innovation and growth.

Debate **Philippe Aghion** (Harvard), **Ufuk Akcigit** (University of Pennsylvania), **Giovanni Dosi** (University of Pisa), **Alfonso Gambardella** (Bocconi University), **Ralf Martin** (Imperial College London)

11:00-11:20 COFFEE BREAK

11:20-12:50 **Session 2: The research – policy nexus**

Questions to be addressed: To what extent has research fed policies on R&D, innovation and growth, in Europe and elsewhere? To what extent are policies ahead of research? What are open policy questions for which there is insufficient scientific knowledge? To the extent that interactions have not been optimal, what are the causes?

Format: Four case studies discussed by policy-makers and academics to feed diagnostic. Each case discussion will last for 45’.

Topic 1: National innovation policies (chair: Estelle Cantillon) (11:20-12:05)

Dominique Foray (Lausanne) “What do we learn about innovation policy from the Swiss model”

Xabier Goenaga (JRC - Knowledge for Growth, European Commission) “Assessment of research and innovation systems: use of country specific analyses and macro-economic models”

Dominique Guellec (OECD), “New industrial policies”

Topic 2: The European patent system reform (chair: Dominique Guellec, OECD) (12:05-12:50)

Bronwyn Hall (UC Berkeley), **Kazuyuki Motohashi** (University of Tokyo) and **Bruno van Pottelsberghe** (ULB)

12:50-13:50 LUNCH

13:50-15:20 **Session 2: The research – policy nexus, continued**

Topic 3: State aid and innovation (chair: Michele Cincera) (1:50-2:35 pm)

Tomasso Duso (DIW and DICE Dusseldorf), **Fabienne Izkovitz** (DG COMP) and **Jean-David Malo** (DG Research)

Topic 4: A historical perspective on the role of economic advice for growth policies in Europe (chair André Sapir) (2:35-3:20 pm)

Werner Roeger (DG EC-FIN, European Commission), **Ramon Marimon** (European University Institute) and **André Sapir** (ULB)

15:20-15:35 COFFEE BREAK

15:30-17:00 Session 3: Data issues and data development (chair: Reinhilde Veugelers)

Questions to be addressed: Do researchers and policy-makers have access to quality data to answer the relevant questions? How do access / data quality vary across country / continent? What progress recent data generation efforts have allowed? What are unmet data needs?

“Insights from the distributed research model to tap confidential firm-level data”, by **Alessandra Colecchia** (OECD)

“Public Funding in Scientific Research and its Relationship to Outcomes: Data Issues and Evidence from Star&U Metrics” by **Jacques Mairesse** (CREST)

“New research and policy insights from EU-KLEMS and WIOD”, by **Marcel Timmer** (University of Groningen)

17:00-17:15 COFFEE BREAK

17:15-18:00 Session 4: An agenda for European research on R&D, innovation and growth? (chair: Estelle Cantillon)

Questions to be addressed: The purpose of this session is to wrap up day by linking all previous sessions to yield conclusions for the way forward in policy-relevant European research on R&D, innovation and growth.

Philippe Aghion (Harvard), **Philippe Keraudren** (European Commission, DG RTD), and **Reinhilde Veugelers** (KU Leuven and BRUEGEL)

18:00 COCKTAIL DINATOIRE

Scientific committee

Estelle Cantillon (ULB, COEURE), Michele Cincera (ULB), Ramon Marimon (EUI, COEURE), André Sapir (ULB, BRUEGEL), Bruno van Pottelsberghe (ULB)

Minutes of the workshop

Estelle Cantillon welcomed the participants at the conference and briefly outlined the key items on the agenda. This was followed by a short presentation by Marianne Paasi (DG RTD) explaining the motivations for the COEURE Coordinating Action and emphasizing its role in providing inputs to a strategic research plan over key economic policy issues of European and EU relevance.

Session 1: What have we learned? What do we still need to know? Setting the stage

The first session was devoted to taking stock of the existing body of research on the themes of R&D, innovation and growth. It was centered on the draft survey prepared by the selected principal investigator (PI), **Philippe Aghion** (Harvard) and **Ufuk Akcigit** (University of Chicago), with the goal to discuss the survey and offer complementary perspectives on these themes.

Philippe Aghion gave an overview of the Schumpeterian approach to modelling growth theory, underlining the central role of competition in that context (*creative destruction*) and illustrating how modelling innovation explicitly has led economists to change the way they think about growth.

The Schumpeterian framework allows to better understand the role of firm heterogeneity, competition and other so-called framework conditions (such as the strength of the rule of law) on innovation, and the consequences of innovation on firm and job turnover, welfare and inequality. Philippe Aghion stressed the role of product and labor market competition on innovation and advocated for a new approach to industrial policy, one that combines competition with support to innovation-intensive sectors (and not firms), and relies on pragmatic ex-post evidence on competitive effects rather than an ex-ante legalistic approach. He also emphasized the impact of the distance to the “technology frontier” of a firm or a country on the interplay between competition and innovation, and its implications for policy: effective policies depend on where the country is relative to the frontier.

The largest part of his presentation was devoted to the policy implications of the Schumpeterian model for advanced economies such as those of the European Union. On top of rethinking industrial policy, he recommended to use the current structural funds to fund the short term costs of structural reforms and called for a more flexible macro policy.

Ufuk Akcigit expanded on the survey by describing the potential that the combination of *macro* models with *micro* data has to better understand the aggregate implications of growth and industrial policies. Indeed, sector-specific and/or market-specific policies may have impacts beyond their sector or market, especially in the presence of effects on aggregate prices, competition or composition / reallocation (i.e. entry and exit of firms).

Ufuk Akcigit documented the potential of these models through some of his recent work that focuses on firms, inventors or inventions, respectively, as their unit of analysis.¹ Firms are largely heterogeneous when it comes to innovation behavior. This raises the issue of which firms to target for R&D subsidies. In some of his recent work, Akcigit and his coauthors have leveraged US census of manufacturing data to show that

¹ “Growth through heterogeneous innovations” with William Kerr, “Innovation, reallocation and growth” (with Acemoglu, Bloom and Kerr), “Taxation and the international mobility of inventors” (with Baslandze and Stantcheva), “Buy, Keep or Sell: Economic growth and the market for ideas” (with Alp-Celik and Greenwood).

R&D subsidies to incumbent firms are not boosting growth. In some other work, he has used US and European Patent Office data to document that top tax rates significantly impact the location choice of superstar inventors and simulate how changes in tax rates would influence the number of domestic and foreign superstar innovators. Finally, his recent work has documented that the (secondary) market for patents is contributing to growth, suggesting an initial *misallocation of ideas*. An open question is how to best organize this market given the large potential gains.

Giovanni Dosi (University of Pisa) introduced his discussion with the dichotomy he saw between existing growth theories that had a hard time explaining short-run macro fluctuations, and business cycle theories (such as new Keynesian models) that do not address long-run issues. The consequences are a form of schizophrenia in macro policies. He reported on recent research (the ISIGrowth project) funded under Horizon 2020 to build evolutionary models able to account for both the short run (the Keynesian perspective) and long run (Schumpeter) aspects of economic fluctuations. Such models emphasize *capabilities* and *opportunities* of innovators over *incentives*. Dosi argued that to achieve long-run growth, Schumpeterian innovation might not be enough and that “Schumpeter should meet Keynes”, i.e. innovation policies should be combined with fiscal policy, allowing for extensive public intervention (i.e. the opposite of what it has been done with the pro-austerity approach), to cope with short-run business cycles.

Alfonso Gambardella (Bocconi University) focused on the importance of firm entry at the technological frontier and on the differences between incumbents and entrants. In this context, the *division of labour* (who does what between entrants and incumbents) is very important. When the market is sufficiently large (like in the US), complementarities between incumbents and entrants might lead to a *vertical division of labour* (or to use another analogy: “Schumpeter meets Stigler”). For instance, in the Silicon Valley, incumbents tend to avoid the competition from new entrants by integrating the start-ups that are often created by people who were previously working as employees for the incumbents themselves. Policy-makers should thus be careful to preserve entry and be very cautious when giving subsidies to incumbents: because of the reason given by Aghion and Akcigit in their survey (subsidies may impede reallocation between incumbents and entrants) but also because subsidies to incumbents may reduce the vertical division of labour.

Ralf Martin (Imperial College London) focused on the link between growth and the environment. Innovation is needed to trigger the production of clean technologies and help the economy transition to what is often called “green growth” in policy circles. The problem is that some of these clean technologies are still immature and more expensive than “dirty” technologies, raising the question of whether the current heavy promotion of clean technologies (for example at the European level) is hurting growth in the short run. A necessary condition for subsidies to clean technologies to be compatible with growth is that the economic spillovers from these technologies are higher than the spillovers from dirty technologies. Recent research based on patent citations confirms that this is indeed the case.² Moreover, those spillovers are also more local, a good argument in the context of unilateral climate change policies. Martin and his coauthors’ explanation for this differential effect is that clean technologies are an emerging field with a higher level of innovation activity. Martin also discussed where to find the budget to finance such subsidies in the current fiscal restriction context.

The presentations were followed by a **discussion with the audience**. Recent research advances and progress on some of the issues covered in the presentations were discussed. Combining data and models are clearly a

² Dechezleprêtre, Martin and Mohnen (2013), Knowledge spillovers from clean and dirty spillovers, mimeo.

way to go but there are still important data limitations, for example on innovation networks or cross-border innovation activities.

The policy implications were also largely discussed. First, it is easy to argue for subsidizing R&D, it is harder to quantify the right level of subsidies. In some cases, it could be that there is already more than enough subsidies. Second, innovation and growth need structural reforms. These are not synonymous with austerity: there are several reforms that could be implemented (even at the level of firms) without tightening fiscal conditions. It is also important to stress that countercyclical policies are important and that in order to be in a position to implement such policies, one needs to run surpluses during good times. Third, policy should also address the dead-end problem (researchers reaching a negative result but not reporting it). Dead-ends lead to useless duplication of effort.

Session 2: The research – policy nexus

The objective of the second session was to assess to what extent research is feeding policies on R&D, innovation and growth in Europe, or to what extent policies are ahead of research and dealing with issues for which too little research is being done. These questions were explored through the lens of four specific policy issues: national innovation policies, patent policy, state aid and innovation, and growth policies in Europe.

National innovation policies

Dominique Guellec (OECD) started his presentation by stating that industrial policy was “born again” after the financial crisis of 2008. New Industrial Policies (NIPs) are essentially innovation policies aiming at changing the industry structure to boost growth and address grand challenges (e.g. environment). They are usually market-friendly, focus on technology (rather than firms) and support entrepreneurship. In that sense, they are very much aligned with the general recommendations of the survey. There remain many open policy questions however when it comes to the implementation. More research is needed here.

1. We need to better understand the economics of mixed incentives (in practice industrial policies involve many actors with different incentives, e.g. in PPPs)
2. How do we tailor policy instruments to context, how do we evaluate them when – as is often the case – several instruments apply at the same time?
3. To what extent should we concentrate funding on a few technologies versus spread the risk? And how do we prioritize across these activities and technologies?

Dominique Foray (Lausanne) discussed the Swiss case, one of the top innovating countries despite the lack of an explicit innovation policy at the national level. He attributed the success of Switzerland to its institutional framework and to the values (and culture) of the country.

1. Science and research are facilitated by the *right* environment (*horizontal policies*: very effective national science foundation, autonomy and governance of universities, well-paid researchers, openness, ...) and firms that can draw on a skilled workforce thanks to a very efficient and effective vocational education system. The country also benefits from supportive local ecosystems (“SMEs are not home alone”). However, Switzerland has to deal with the side effect of its highly successful vocational education system. Its main components make it so attractive (dual learning mechanism, high commitment of firms, effective tertiary B, students paid from the beginning) that about 70% of

young Swiss do not enter the general/academic route, making the system extremely reliant on foreigners to fill in the highly skilled positions.

2. Innovation is also stimulated by a mix of culture and anti-elitist values that reward (socially) practical knowledge and private initiative: most collective action problems are solved by companies themselves and there is no *etat stratège*.

During the discussion, several people drew a parallel between the Swiss and the German educational systems, emphasizing that despite their similarities, the innovation performance of Germany is worse. This calls for further research.

Xabier Goenaga (JRC) described three assessment methodologies that are commonly used to evaluate policies: qualitative analysis, ex-post assessment (econometrics) and ex-ante assessment (macro-economic models). While qualitative assessments are being abandoned, ex-post econometric exercises are currently very much used. Evaluations based on macro-economic models are likely to become an important tool for policy development (for example as a guide to decide on the allocation of structural funds). However they need to be further improved and refined, for example to include estimated elasticities, account for the quality of research activities or how public and private R&D interact.

Patent policy

Dominique Guellec provocatively opened the second part of the session by saying that many in Europe think that the US patent system does not work well. However, the innovation performance of the US is much better than the innovation performance of the EU. Why is this?

Bronwyn Hall (University of Berkeley and Maastricht University) answered Guellec's question by saying that the causality may be reversed: innovative activities and innovators create the patent system and not the other way around. The policy trade-off is that some reward is needed to encourage innovation but, at the same time, openness reduces the cost of innovation. Innovation creates growth via diffusion, which is really a form of imitation. For firms and countries that are not at the frontier, intellectual property protection can actually impede development.

There are stark differences between the US and Europe when it comes to researchers' input to patent policy. In the US, legal and economic researchers have greatly contributed to shape the current patent system (for example the introduction of the post-grant review as a way to reduce litigation costs). Such fruitful interactions between researchers and policymakers are not happening as much in Europe as far as patent policy is concerned.

Discussion of the current system in Europe has been highly biased towards incumbents. Potential entrants and consumers are rarely represented. This is a situation that is difficult to change as the main beneficiaries of the current system are few and the potential beneficiaries are many but have each only little to gain from such a change (Interestingly, in the US, the development of patent trolls changed the balance of power.) She ended with two open questions for patent policy in Europe: (1) The goal is a unitary patent system but the current hybrid (EPO, EP, and national offices) may not achieve that goal; (2) Should national patent offices survive?

Kazuyuki Motohashi (University of Tokyo) reported on some of his recent research on software patents. Software patents exist in the US but not in Europe and it is an open question whether they encourage or discourage innovation. His research exploits a change in software patent protection in Japan. He found

increasing licensing of software as a result of the increased protection. In turn, increased licensing impacts competition in the market that uses software. More research is needed however.

Bruno van Pottelsberghe (Université Libre de Bruxelles) introduced his talk by documenting the diversity of patent policies across the world. There are large variations in the concept of what is a patentable *idea* and this diversity of systems is an impediment to the creation of single market. One open policy question for which more research is needed concerns the impact of the quality and system design on innovation (this goes back to the questions introduced by Guellec). The European patent system is viewed as high quality but high costs due its different national layers, and it delivers less innovation than the US. The system needs reform but the current governance (with the national offices) is working against it because each office wants to keep its sources of revenues. Real coordination at the EU level is needed to avoid the creation of yet another layer that would only add bureaucracy.

In the discussion, there was a consensus about the desirability of a system closer to the one of the US, with a two-tier system where patents may be of lower quality but granted faster and at lower cost. Such a system is more favorable to start-ups. Many doubted that the current European system is doing what firms actually need.

State aid and innovation

Michele Cincera introduced the session by reminding the audience about the market failure rationale for state aid, but also the multiple dimensions of policy evaluations (dynamic efficiency, effectiveness, ...).

Tomaso Duso stated there is very little evidence on the impact of industrial and competition policies on actual competition, innovation and growth. Some of his work has found evidence of a positive link between the quality of competition policy and productivity growth.³ Other work has also investigated the competitive effect of research joint ventures (RJVs) that often benefit from a more lenient treatment under competition policy and found that they can facilitate collusive behaviour in the product market.⁴

State aid can be seen as a hybrid between competition policy and industrial policy but empirical evidence here is even scander. The reasons are that the objectives pursued by state aid are multiple (balancing test: is it addressing an objective of a common interest, does it significantly distort competition, is it appropriately targeted, ...) and that state aid is often only one element of a scheme (together with other policy instruments). This raises important identification challenges.

Fabienne Ilzkovitz (DG COMP) reviewed the arguments and counter-arguments for the claim that R&D and innovation intensive industries need a different treatment under competition policy. The arguments in favour of a different treatment hold that:

- market power is less of a concern in these industries due to rapid technological changes,
- tough competition policy enforcement can reduce incentives for innovation,
- merger policy does not sufficiently take dynamic effects of innovation into account,

³ Buccirossi, Ciari, Duso, Spagnolo and Vitale (2013), Competition policy and productivity growth : an empirical assessment, *Review of Economics and Statistics*, 95(4).

⁴ Duso, Röller and Seldeslachts (2014), Collusion through joint R1D: An empirical assessment, *Review of Economics and Statistics*, 96(2).

- restrictive state aid policies and the associated heavy administrative burden defeat the purpose of state aid (in terms of correcting for a market failure).

On the other side, arguments against a different treatment of these industries hold that:

- rapid technological change does not prevent market power problems and some features of these industries (such as network effects) are actually favourable to the establishment of market dominance,
- the evaluation of dynamic effects of mergers is already part of the standard merger assessment process,
- many of the criticisms against the EU state aid policy have been addressed by the State Aid Modernisation of 2014.

Ilzkovitz argued that, in her view, the current competition policy framework at the European level was adequate to deal appropriately with the specificities of R&D and innovation intensive industries but stressed the need for stronger evidence on the relation between competition policy and innovation, including the need to develop the analytical underpinnings and practices of ex-post economic evaluations of decisions by competition authorities.

Richard Cawley (DG Research) started his discussion by the inverted U relationship between competition and innovation, stressing the need to know where we are on the curve before being able to generate policy recommendations. Existing evaluation methods are mostly static and thus unsatisfactory to assess dynamic effects. We might therefore take a negative decision on the basis of a static model whereas an appropriately dynamic (ideally dynamic general equilibrium) would have led to a positive decision.

A major concern emerging from the **discussion** was whether competition policy is also a tool to achieve market integration and if this is the case, whether regulation would not be a better instrument.

A historical perspective on the role of economic advice for growth policies in Europe

André Sapir (Université libre de Bruxelles) opened the session by saying that the interaction between policy-makers and academics is instrumental to improve policy outcomes, and that, at least since the 70s, prominent economists have been involved, directly or indirectly, in the development of policies at the level of the EU institutions and the Euro. The golden times for these interactions were the 1980s. These interactions can happen in several ways (they do not need to be face to face) but it is important to understand when they work well.

Ramon Marimon (European University Institute) shared his experience in drafting of the Lisbon agenda (i.e. the one of the famous 3% target – R&D expenditure over GDP). He argued that, even though the target was clearly missed at the EU level, some countries have done (and do) better than others, even during the crisis. In fact, the crisis has led to an R&D divide: not all the countries have reduced R&D expenditures due to tighter fiscal conditions.

Werner Roeger (DG ECFIN) said that an important example of fruitful interactions between policy and research is the EU/KLEMS project. The motivation for the EU/KLEMS project was to better understand the reasons for the divergence in TFP growth between the US and the EU. It led to the development by researchers of a dataset that has subsequently been widely adopted for policy-making. It is still unclear however why Europe has fallen behind. Is it because Europe runs behind in producing and/or using IT? Why

is the recovery so slow? Is it a structural or a cyclical problem? Is it a demand or a supply problem? Or both? The problem is that, even though the problem is in Europe, most of the academics involved in the debate are US-based and therefore tend to ignore some of the European specificities. The Juncker Commission seems to have made up its mind by focusing on the lending channel, labour market policy, etc. ... with human capital and R&D taking a back seat. He ended by inviting the European academic community to enter the debate.

André Sapir started by recalling the context of the Sapir report. The context then was much more favourable but they still thought Europe had a growth problem: Europe was not innovating enough, its GDP per capita was stuck at around 70-80% of the US GDP per capita. The report focused on growth-related supply-side reforms.

Today's context is different but the challenges that were identified then (aging, globalization, ...) are still present. However our capacity to react is smaller. The academic community may have wasted time arguing whether it is a demand or a supply problem. Both types of problems are present (though maybe not in the same proportion in all countries). Economists need to coordinate to be credible when crises hit. There is both a demand and a willingness to supply advice at the European level.

One of the participants reacted to this last point during **discussion** by arguing that the demand for advice at the European level was also very fragmented and that this reduced the ability to inform the policy debate effectively. Another underscored one striking difference between Europe and the US that is still not fully understood: Europe is less sensitive to macroeconomic shocks (i.e. the US are usually more heavily hit in the very first place) but also takes much more time to get back (if it does) to pre-shock growth trends. This is related to the structure of the economy but we need to better understand the mechanisms behind this.

Session 3: Data issues and data development

The objective of session 3 was to assess the quality of data available to researchers and policy-makers and identify existing unmet data needs. **Reinhilde Veugelers** (KU Leuven) introduced the session by noting the increasing call for evidence-based policy-making. There are two dimensions to the evidence part: evidence on the policy levers (mechanisms at play), and evidence on the effectiveness of policy interventions. Both require micro and macro datasets that are sufficiently granular to capture the relevant sources of heterogeneity and cover a sufficiently long period to be able to assess dynamic effects. Convincing evidence also requires common (and state of the art) methodologies to allow comparisons across different datasets.

Alessandra Colechia (OECD) described the current push at the OECD to exploit the potential of linked micro data from multiple countries, the distributed model. Most of the interesting firm level or administrative datasets are still national. The OECD has put in place a data infrastructure that promotes greater harmonization and allows for a statistical analysis on linked datasets (e.g. tax records and employment records) of multiple countries. The great advantage of this distributed model is that one can now run the same specification on the different national high-quality datasets (given the confidentiality of these data and the effort needed to access them and link them, a typical researcher would focus on a single country). She discussed new evidence about SMEs that this distributed model has been able to generate, namely that it is

mostly young SMEs that create jobs, that their growth dynamics differs across countries and that start-up rates have declined generally.⁵

Such initiatives are resource-intensive and require the cooperation of national statistical offices. There remain important differences across OECD members regarding the quality of their data and willingness to link. However she argued that the distributed model is a pragmatic way to address issues of access to data and help improve the relevance and usability of official statistics. The model also helps build the case for the development of linked micro data statistical infrastructures in countries and for improved access to micro-data by researchers. With regard to data needs for R&D, innovation and growth, she pointed to Blue Sky 3.

Jacques Mairesse (CREST) presented preliminary results of an ambitious administrative data collection project with Julia Lane, Michele Pezzoni and Paula Stephan aimed at understanding the relationship between public funding of universities and research outcomes in the US (STAR METRICS). The data will eventually contain detailed information for all federal funded projects in US universities, including the staff hired by the projects and the project outcomes. There are three methodological issues that we need to address to be able to assess the causal link between funding and research outcomes: attribution (which article can be attributed to which funding source?), bundling (does the way in which funding is bundled matter?), and scaling (how does research output vary with the level of research funding?). Jacques Mairesse showed how one can address the first two issues using the type of panel dataset, produced by STAR METRICS, tracking both researchers and research projects over time.

Finally, **Marcel Timmer** (University of Groningen) presented the EU-KLEMS and WIOD European Commission-funded projects. EU KLEMS was built with the view to enable greater use of the country-industry-time dimension to investigate the drivers of productivity growth and demand for labour. It has become the standard industry-level database used by researchers and policy-makers alike (cf. the discussion of Werner Roeger in session 2). Unfortunately, this did not guarantee its survival as it has failed to be taken up by Eurostat (it has been taken up and will therefore be updated by some national statistical offices). There are other promising linked initiatives taking place, including the Innodrive and Coinvest projects on intangibles and the World Input-Output Database (WIOD) project that adds the international trade dimension and the demand side. WIOD which brings together 12 research institutes coordinated by the University of Groningen will allow for a better understanding of global value chains (GVCs), a core aspect of globalization. Its strength lies in its methodology grounded in the official national accounts statistics. A lesson learned from EU-KLEMS is the value of opening up the database early to foster contributions and take up by the statistical community.

Session 4: An agenda for European research on R&D, innovation and growth?

The objectives of the last session were to summarize the lessons and issues from the day and address in particular three questions:

- How will research on “R&D, innovation and growth” look like 10-15 years from now? Are there specific themes that should be encouraged?
- How should we bridge the research – policy gap ?
- What is the best way to support European-based researchers working on R&D, innovation and growth ?

⁵ Criscuolo, C., P. Gal and C. Menon (2014), The dynamics of employment growth: new evidence from 18 countries, *OECD STI policy paper*.

Estelle Cantillon introduced the panel by summarizing a few facts about research in the field based on a bibliometric analysis of all articles on R&D, innovation and growth published between 1994 and 2014 (see annex for details). The data show that, over the past twenty years, European-based researchers have seen their share of publications increase (from about 40 to 50% of all publications) but their share of top publications has remained fairly constant around 30%. This matters because there tends to be a home bias in empirical work (researchers from Europe tend to work more on European data; researchers based in the US tend to work more on US data, ...) and top publications have also much more impact than other publications. So it is important to keep a base of researchers working on these topics in Europe and continue to encourage them to publish at the highest level. The share of empirical papers has remained fairly constant (at 70%) over the past 20 years but the average number of authors per article has steadily increased, a trend that is seen elsewhere in economics.

Philippe Aghion, Philippe Keraudren (DG RTD) and **Reinhilde Veugelers** were the panelists. On the first question, **Philippe Keraudren** stressed the idea that more fundamental research is needed and regretted the current fragmentation of research funding at the EU level. On the content, he stressed the importance of preserving the existing variety of thoughts and traditions in economics and encouraging inter-disciplinarity. **Reinhilde Veugelers** argued that big data, open access and shared platforms are likely to shape the future of research in the field. She advocated for greater trust of researchers and, in particular, to not underestimate the policy relevance of “bottom up” / basic research, even if one needs a mix between the different types of research. Jumping to the last question, she stressed the need for support to research data infrastructure to fully unleash the potential of big data: the building and maintenance of large datasets and data infrastructure entail large fixed costs and some public good components. **Philippe Aghion** rejoiced about the increasing dialogue between micro and macro in the area of R&D, innovation and growth, an increasing integration fostered by data availability. There are still challenges: we still need more dynamics, development and growth need to come closer together and so do trade and growth and the literature on the internal organization of firms. But the trend is clear and it works towards the convergence of these multiple literatures with huge potential payoffs. He was also excited about the greater dialogue between theory and data in the field because the combination will discipline research on these topics. This is an active field of research and one that will continue to be active for a while.

Around the second question, *How should we bridge the research - policy gap?*, several opinions emerged. **Philippe Keraudren** acknowledged that the relation between policy and research can sometimes be very frustrating. Economists are nonetheless one of the most successful disciplines in terms of influencing policy makers. There is thus space for them in the public debate, provided they can communicate their expertise adequately (less jargon). Think tanks are also a good way to link science to policy-making: they have the capacity to transform a scientific discourse into a policy-relevant one. **Reinhilde Veugelers** viewed the debate as a question of vertical specialization. We do need researchers that work on policy-relevant issues and we need policy-makers that are able to absorb policy-relevant research. There is a role here for intermediaries such as think tanks or platforms where academics and policy-makers meet regularly. Life-long training of policy-makers to update them about the state of research throughout their career would be useful too. **Philippe Aghion** stressed that the key is to produce the best possible research, then transform it into a policy brief to disseminate it to policy-makers.

Participants

First Name	Last Name	Affiliation
Philippe	Aghion	Harvard University
Ufuk	Akcigit	University of Pennsylvania
Tommaso	Aquilante	Université libre de Bruxelles
Beñat	Bilbao-Osorio	European Commission, DG RTD
Estelle	Cantillon	Université libre de Bruxelles
Richard	Cawley	European Commission, DG RTD
Barbara	Chizzolini	Bocconi University
Michele	Cincera	Université libre de Bruxelles
Daria	Ciriaci	European Commission, DG ECFIN
Alessandra	Colecchia	OECD
Guido	Cozzi	University of St Gallen
Benedikt Hermann	Dengler	European University Institute
Giovanni	Dosi	University of Pisa
Tomaso	Duso	WZB Berlin and DIW
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Speakers' bios

Philippe Aghion is the Robert C. Waggoner Professor of Economics at Harvard University, and a fellow of the Econometric Society and of the American Academy of Arts and Sciences. His research focuses on the economics of growth. With Peter Howitt, he pioneered the so-called Schumpeterian Growth paradigm which was subsequently used to analyze the design of growth policies and the role of the state in the growth process. Much of this work is summarized in their joint books *Endogenous Growth Theory* (MIT Press, 1998) and *The Economics of Growth* (MIT Press, 2009), in his book with Rachel Griffith on *Competition and Growth* (MIT Press, 2006), and more recently in his handbook survey "What Do We Learn from Schumpeterian Growth Theory." In 2001, Philippe Aghion received the Yrjo Jahnsson Award of the best European economist under age 45.

Ufuk Akcigit is an assistant professor of economics at the University of Pennsylvania and a Faculty Research Fellow at the National Bureau of Economic Research. His research interests are in macroeconomics, economic growth, technological change, productivity, firm dynamics, and the economics of innovation.

Richard Cawley has been working at the European Commission since 1983 (in various DGs) and is currently economic advisor to the Financial Engineering unit at DG Research and Innovation. He is also a Research Associate at Delft University of Technology and a Fellow of the Centre for Science and Policy, Cambridge University. He studied at Leicester University and Cambridge University (Mathematics), Simon Fraser University (Economics) and holds a PhD from Delft University.

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Giovanni Dosi is professor of economics and Director of the Institute of Economics Scuola Superiore Sant'Anna in Pisa (Italy). He co-directs the task force on Intellectual Property Rights at the Initiative for Policy Dialogue, an initiative led by Joseph Stiglitz at Columbia University and is coeditor of *Industrial and Corporate Change*. His major research areas include Economics of Innovation and Technological Change, Industrial Economics, Evolutionary Theory, Economic Growth and Development, and Organizational Studies.

Tommaso Duso is Head of the Firms and Markets Department at the Deutsches Institut für Wirtschaftsforschung (DIW Berlin) and professor at the Düsseldorf Institute for Competition Economics (DICE). His research interests are in applied econometrics in the fields of industrial organization, competition policy, regulation, and management.

Dominique Foray is Full Professor at the Ecole Polytechnique Fédérale de Lausanne (EPFL) and holds the Chair of Economics and Management of Innovation (CEMI). He is a member of the National Research Council (Switzerland); the Advisory Board of the Swiss Economic Institute (KOF); and a foreign member of the Center of Capitalism and Society (Columbia University, New York). He is also a new member of the Expert Commission for Research and Innovation (E-FI) of Germany. From 2008 to 2011, he served as chairman of the expert group "Knowledge for Growth"; a group of prominent economists created to advise the European Commission. This is during his service as member of this Group that he developed the concept of smart specialisation (together with P.A. David and B. Hall) that is now a key policy mechanism of the EU (cohesion policy).

Alfonso Gambardella is a professor in the department of Management and Technology at Bocconi University. His research studies how technology and innovation affect and are affected by company strategy, industry structure, and policy and has covered both micro and managerial issues but also industry level and even more macro phenomena. He is co-editor of the *Strategic Management Journal*.

Xabier Goenaga is responsible for the Innovation Systems Analysis Unit of the JRC of the European Commission in Brussels, which amongst other supports the preparation of Country Specific Recommendations in the field of research and innovation. Between 2007 and 2015, he was responsible for the Knowledge for Growth Unit of the JRC in Seville.

Xabier Goenaga is a graduate from the Basque Country University. He holds a PhD in chemical engineering from the University of Wales and a Master degree in Public administration from the École Solvay in Brussels.

Dominique Guellec is head of Science and Technological Policy at the Directorate for Science, Technology and Industry of the OECD.

Bronwyn Hall is Professor of Economics Emerita at UC Berkeley and Professor of Economics of Technology and Innovation at Maastricht University. Her current research includes comparative analysis of the U.S. and European patent systems, the use of patent citation data for the valuation of intangible (knowledge) assets, comparative firm-level investment and innovation studies (the G-7 economies), measuring the returns to R&D and innovation at the firm level, analysis of technology policies such as R&D subsidies and tax incentives, and of recent changes in patenting behavior in the semiconductor and computer industries. She has made substantial contributions to applied economic research via the creation of software for econometric estimation and of firm-level datasets for the study of innovation, including the widely used NBER dataset for U.S. patents.

Fabienne Ilzkovitz is principal advisor for economic evaluation of competition policy in the Competition Directorate General of the European Commission (DG COMP) and an associate professor in the Solvay Brussels School of Economics and Management of the Université Libre de Bruxelles. Previously, she was director responsible for the implementation of EU competition policy in the area of transport and post at DG COMP and has held several positions as head of unit in the Directorate General for Economic and Financial Affairs of the European Commission. Before joining the Commission, she worked as research assistant at the Université Libre de Bruxelles and in the research department of the National Bank of Belgium. Her research interests include European integration, competition policy and industrial economics.

Philippe Keraudren holds a PhD in political science and a "Habilitation à diriger des recherches" in political science from the Institute of Political Studies in Paris. He specialised in the area of public sector innovation, notably at the European Institute of Public Administration in Maastricht, before joining the Commission at DG SANCO, working on consumer protection in services of general interest. He then occupied several posts in DG RTD and is now acting Head of Unit at DG RTD in Unit B6 ("Reflective Societies") where he supervises the integration of social sciences and the humanities (SSH) across Horizon2020, the international dimension of SSH as well as the impact of the SSH European programme on science, society and policies.

Jacques Mairesse is professor of applied econometrics of research, innovation and productivity at the University of Maastricht, a researcher at CREST and a research associate at NBER. His research focuses on the field of production economics broadly understood, ranging from questions of measurement of various forms of capital and problems of implementation of panel data econometrics, to behavioral assessment and performance evaluation in different institutional contexts and at various levels of analysis (individual employee or researcher, firm or scientific laboratory, industry or scientific field, private or public organization, country).

Ramon Marimon is professor of economics at the European University Institute and UPF – Barcelona GSE (on leave). He is affiliated with NBER and CEPR and is chairman of the Barcelona Graduate School of Economics. He was Secretary of State for Science and Technology in Spain (2000-02) and has served in several Expert Groups advising the European Commission on R&D and Higher Education policy. His research interests include macroeconomics, monetary theory, contract theory, learning theory and labor theory.

Ralf Martin is an assistant professor of economics at Imperial College Business School. His research examines how government policies affect business performance. He is particularly focusing on Climate Change policies, to understand which policies are most effective and efficient in reducing greenhouse gas emissions and what effect these policies have on other aspects of business performance.

Kazuyuki Motohashi is professor in the Department of Technology Management for Innovation at the University of Tokyo. His research interests cover a broad range of issues in economic and statistical analysis of innovation, including

economic impacts of information technology, international comparison of productivity, national innovation systems focusing on science and industry linkages, and SME innovation and entrepreneurship policy.

Werner Roeger is head of the unit "econometric models and medium term studies" at the Directorate General for Economics and Finance at the European Commission in Brussels. He received his PhD from the University of Freiburg (Germany) and worked at the Institute for Applied Economic Research at the University of Tübingen before joining the European Commission in 1988. In 2001 he was a visiting professor at Humboldt University in Berlin. In his work within the Commission he is responsible for developing and maintaining the international macro model QUEST III and for the regular calculation of medium term projections and output gaps for EU member states. His research interests focus on quantitative analysis of fiscal and structural policies as well as the analysis of external and internal imbalances.

André Sapir is University Professor at the Université Libre de Bruxelles, Senior Fellow at Bruegel, the Brussels-based think-tank and Research Fellow of CEPR. From 2011 to 2015 he was co-chair of the Advisory Scientific Committee and General Board member of the European Systemic Risk Board (ESRB). From 2005 to 2009 he was member of the Economic Advisory Group to European Commission President José Manuel Barroso. Previously, he served 12 years as Economic Adviser at the European Commission, first to the Director-General for Economic and Financial Affairs and to President Romano Prodi. André Sapir has written extensively on various aspects of international economics, including European integration, monetary union, international trade, international policy coordination and globalization.

Marcel Timmer is professor of economic growth and development at the University of Groningen. He has been leading large-scale research projects funded by the European Commission, including the EU KLEMS project and the World Input-output Database (WIOD) project. In these projects, new data and models were developed to increase our understanding of the causes and consequences of increasing global integration and growth. These databases are currently been taken up in the official statistical community and proved to be highly relevant for policy research. He is an advisor to the World Bank, OECD and Statistics Netherlands, the lead author of Economic Growth in Europe and published various articles in leading academic journals.

Bruno van Pottelsberghe is Dean of the Solvay Brussels School of Economics and Management at the Université Libre de Bruxelles and Senior Research Fellow at BRUEGEL, a Brussels-based Think-Tank. His research interests focus on the effectiveness of science and technology policies, patent policies, regulations and innovation. He was Chief Economist of the European Patent Office (EPO) from 2005 to 2007, and serves as an Advisor to the President and Rector of the ULB for technology transfer issues.

Reinhilde Veugelers is professor at KU Leuven and a Senior Fellow at BRUEGEL. She is a member of the Scientific Council of the ERC and recently (2004-08) served as advisor to the European Commission (BEPA Bureau of European Policy Analysis). Her research combines analytical frameworks, using micro-economics, game theory and economics of information models, with empirical, mostly econometric testing on large datasets. Recent topics include cooperative R&D, international technology transfers through MNEs, young innovative companies, innovation for climate change, and industry science links. She is the coordinator of FP7 funded project SIMPATIC whose goal is to provide policymakers with a comprehensive and operational tool box allowing for a better assessment of the impact of research and innovation policies in Europe.

Annex: Details for bibliometric analysis

For the purpose of session 4, the following data were collected analyzed. We used the Econlit database from which we selected all journal articles published between January 1994 until December 2014 and assigned to one or more of the following JEL codes.⁶

- O30 Innovation; Research and Development; Technological Change; Intellectual Property Rights: General
- O31 Innovation and Invention: Processes and Incentives
- O32 Management of Technological Innovation and R&D
- O33 Technological Change: Choices and Consequences; Diffusion Processes
- O34 Intellectual Property and Intellectual Capital
- O35 Social Innovation
- O38 Technological Change: Government Policy
- O39 Technological Change: Other
- O40 Economic Growth and Aggregate Productivity: General
- O41 One, Two, and Multisector Growth Models
- O43 Institutions and Growth
- O44 Environment and Growth
- O47 Empirical Studies of Economic Growth; Aggregate Productivity; Cross-Country Output Convergence

The information we collected is information on the title, author names, authors' affiliations, journal, abstract, keywords, geographic descriptors and geographic regions. In total, the dataset comprises 42,976 published articles. We then obtained the number of citations for each article using Google Scholar.⁷

The final dataset contains the following variables: Year (indicates year from 1994 to 2014), Title, Author (string variable containing *all* author names), Affiliation (string variable containing information on all authors' affiliations), Journal title, Abstract (string variable containing the first 244 characters), JEL Codes, Keywords, Geographic descriptor (string variable containing geographic descriptor if applicable), Geographic region, Number of citations.

Number of authors per paper

To compute the number of authors, we exploited the fact that the names of authors in the string variable 'Author' are separated by the symbol '&'. In the beginning, we set the variable equal to 1. Then, we ask STATA to find '&'. If it finds one, the variable 'Number Authors' becomes 2. We repeat this procedure 4 times. This means that the variable takes 1, 2, 3, 4 or 5 as value whereas 5 also contains the case of 6 or more authors. The table describes the result.

⁶ A drawback of this approach is that we likely overestimate the number of articles of the 'pure' R&D and innovation literature. We cannot distinguish between articles that have R&D and innovation as main topic and those where it only plays a minor role.

⁷ We use the information on the title to perform the search on Google Scholar. We force to only return results where each word in our query is in the title of a given work. Since titles may be ambiguous, we use the (first) surname of the author(s) in the search process. Then, we retrieve the information on the number of citations from the first paper in the results list.

number Authors	Frequency	Percent	Cum.
1	19,700	45.84	45.84
2	15,509	36.09	81.93
3	6,301	14.66	96.59
4	1,179	2.74	99.33
5	287	0.67	100.00
Total	42,976	100.00	

Papers by region

To assign each article to its origin region, we use the authors' affiliations. In the simplest case, there is a single author, based in a single university. The paper is then assigned to the region (Europe, Asia, North American, Other). When the article is written by several authors each affiliated with a university, the share of the article assigned to a region correspond to the share of authors from that region. If an author is affiliated to several institutions in several regions, then his/her share of the article is equally distributed across those regions. 94.4% of articles could be assigned to one or several regions (the missing assignments are due to missing or unknown affiliations).

Top publications

Articles are considered top publications if they were published in the American Economic Review, the Journal of Political Economy, the Quarterly Journal of Economics, Econometrica or the Review of Economic Studies.

Empirical papers

A paper is considered an empirical paper if it has a non-empty "Geographic Descriptor" field (this field is usually used to describe the geographic coverage of datasets). This is a very simplistic way but the most systematic and reliable one. Assigning articles according to keywords in the abstract turned out to be not feasible using Stata because length of strings is limited so that most of the abstract could not be used. Furthermore, the assignment would have been noisy as well as some keywords can appear both in theoretical and empirical papers. For each empirical paper, we assigned a geographical region based on the geographical coverage of the data used (as proxied by the geographic descriptor). If a paper used data from several regions, the paper is assigned to each region in equal proportion.

To compute the "home bias" in geographical coverage for empirical papers, we took, for each region, the papers written by authors in that region and computed the fraction of them using data from that region (papers with authors affiliated to different regions only count for the fraction of authors in that region; papers using data from different regions are assigned according to the fraction that the region represents among the datasets). The data suggest that there is some "home bias": 62% of empirical papers written in Europe use European data, 48% of empirical papers written in the US use US data, 76% of empirical papers written in Asia use Asian data.