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Different recipes for the same dish: comparing policies for scientific excellence across different countries

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Keywords: excellence; science policy; coordination; differentiation; Matthew Effect

1. Introduction

In many countries promoting scientific excellence has become the primary target of science policy. A generic measure is to make research funding conditional upon performance. Several countries have introduced performance-based research funding system in which resources are directed towards excellent performers (Hicks 2012; Lewis & Ross 2011; Lewis 2015; Jonkers & Zacharewicz 2016). In addition, funding has shifted from institutional core funding to competitive project funding (Lepori *et al*. 2007; Jongbloed *et al* 2015). In a recent report, the OECD observed the emergence of research excellence initiatives (REIs) aimed at encouraging 'outstanding research by providing large-scale, long-term funding to designated research units, with an emphasis on research of exceptional quality.' (OECD 2014, p. 20).

Excellence policies work under two assumptions, which often remain implicit in policy documents. The first assumption is that concentrating resources in the hands of a small number of excellent performers has positive effects on the vitality, attractiveness and productivity of the system as a whole. A concentration of resources can refer to individuals and groups within institutions and scientific fields, where the effects derive from selecting of the 'best' over the rest. It can also refer to an institutional or geographic location, where the effects emerge from economies of scale and scope and from proximity (Heringa *et al*. 2014; Bonaccorsi & Daraio 2005; Frenken *et al*. 2009). Policies aimed at creating centres of excellence may achieve either or both types of effect.

The second assumption is that the positive effects of this concentration outweigh the negative effects of providing relatively fewer resources to the remainder of the research community. This efficiency argument is common to all public funding schemes: through differentiation excellence policies create system-wide additionality, which involves outcomes that would not have happened without the policy intervention (Tyler *et al*., 2009; Bloch *et al*. 2014; Bloch & Sørensen 2015).

What is lacking is a systematic understanding of the functioning of excellence policies. It seems that countries each use 'different recipes for the same dish'. That is, they all aim to improve the performance of their science system by providing selective support for high-performing individuals or organisations but they have implemented very different policy instruments to this end. Individual policy instruments have been evaluated, but the effects – particularly on the relationship between policy design and effectiveness – have not been compared across policies or across nations. Scientific studies of the level and determinants of excellence (e.g., Baccini *et al*. 2014 and Diniz-Filho *et al*. 2016 for individuals; Verbree *et al*. 2015 for groups; Noyons *et al*. 2003 for institutions) often take an endogenous perspective – defining performance as a result of internal resources, leadership, network management, funding or institutional and field characteristics – and ignore or keep implicit the exogenous policy environment.

The aim of this paper is twofold. First we wish to improve our understanding of the functioning and effects of excellence policies. Moreover, the paper contributes to broader debates about the ways in which science systems convert inputs into desirable outputs. We define excellence policies as policies that aim to increase differentiation in the science system by providing selective support to a limited number of researchers, groups or organisations that perform very well (or show the potential to do so). Hence, this paper addresses two research questions, namely:

1) How can excellence policies of different countries be characterized and compared in a systematic way?
2) What are the effects of different excellence policies on the differentiation of resources and performances between organizations in the science system?

The paper concentrates on specific excellence policies and their effects, deriving systematic lessons from a cross-national comparison of policy instruments. To understand how an excellence policy produces effects, one needs in-depth knowledge about its design, logic, implementation and functioning. Excellence policies have a common rationale. Yet, their policy design and implementation vary widely, and they target different levels of aggregation (from individuals and groups to consortia and institutions). Natural experiments – comparing researchers who are subject to a policy with researchers who are not – tend to focus on a single instrument and to treat implementation and functioning as a black box (Azoulay *et al*. 2013) This is why this paper adopts a case study approach.

In this paper we compare four specific policy instruments in four countries, namely the *Research Excellence Framework* (REF) in the United Kingdom, the German *Excellence Initiative*, *Centres of Excellence* (CoE) funded by the Danish National Research Foundation (DNRF), and the Swiss *National Centres of Competence in Research* (NCCR).

For each case, we analyse the current degree of differentiation in terms of performance and resources; the logic, design, and implementation of excellence policies; and their effects on differentiation in the science system. The analysis is based on secondary sources such as evaluation reports, international comparative reports (Bennetot & Estermann 2014; OECD 2014) and academic literature (Langfeldt *et al*. 2015). In addition, we interviewed 14 policy experts across the four countries.

We first develop a theoretical framework to explain how excellence policies produce effects (section 2). After a brief explanation of methods and case selection (section 3), we describe the four excellence policies and the context of their national science systems (section 4). Next, we present the results of our analysis and comparison of individual case studies (section 5). We present our main conclusions and discuss their implications in section 6.

2. Theoretical framework: additionality through coordination

Science is a complex adaptive social system (Heimeriks 2009) in which outcomes are produced through the actions of, and interactions among, autonomous actors at different levels (researchers, group leaders, faculty deans, universities, research councils, government departments, etc.). Complex adaptive systems produce emergent outcomes at system level, such as national science portfolios, patterns of collaboration, and levels of performance.

Policy intervenes in the self-organisation of science. Without policy, science also produces coordinated outcomes. However, those outcomes may diverge from what is desired. Science may not produce (or under-produce) the desired outcomes, such as female professors and managers, societal impact, or a selective rather than a diverse portfolio. Moreover, outcomes may be produced in the 'wrong' location. Whereas science policy is mainly national and benefits of investments in Research and Development (R&D) are expected within national borders, the organisation of science is often transnational, the benefits of research are collective, and (top) researchers are internationally mobile.

Excellence policies are grounded in the belief that differentiating resource allocations will produce better system performance. Governments hope that concentrating resources in the best research performers will make the science system more effective and yield more and better outcomes for the entire system. From this perspective, excellence policies are designed to produce outcomes that would not have happened without the intervention, namely *system-wide additionality* (Tyler *et al*. 2009) including for example (Bloch *et al*. 2014):

a) new research activities that would not otherwise have been possible ('input additionality');

b) new products and/or publications ('output additionality');
c) research and publications strategies, international collaborations, etc. ('behavioural additionality');
d) changes in workplace mobility ('career additionality');
e) changes in institutional research environments ('institutional additionality').

However, achieving desired outcomes requires coordination, which involves 'organizing social action in a world where there is no overall mind' (Lepori, 2011, p. 359). To enable the desired behavioural changes – and their associated additionalities – governments must provide incentives to put policy into practice. Hessels' (2013) heuristic framework is a useful tool to map the aspects that shape the progression from policy design to outcome. It includes seven coordination aspects, the first five of which we will use to systematically characterise and compare different excellence policies. The last two aspects are the mechanisms for coordination and the kind of performance the coordinator aims to advance. In the case of excellence policies these two will hardly vary across cases. The former generally means rewarding outstanding research to overcome the risk associated with project funding, while the latter means strengthening vertical differentiation in the system.

The five aspects used to address the paper's problem include:

1) the coordinating actor: in the domain of excellence policies, various organisations may function as the coordinating actor, ranging from a federal ministry to a research council or a dedicated high-level committee;
2) the system addressed: research coordination can address systems of various levels of aggregation, such as a research group, a scientific field or a set of funding instruments. Excellence policies usually address a national science system, but there are also instances of international coordination, as is the case for the European Research Council;
3) the activities subject to coordination: excellence policies tend to coordinate *research* activities of individual scientists, groups or research organisations;
4) the interventions taken: the interventions of most excellence policies concern the introduction of funding instruments. These instruments can vary in size and duration, degree of collaboration, interdisciplinarity, and the selection of new versus established projects;
5) the types of relationships that are established or strengthened: a variety of relationships may be involved in research coordination, such as collaboration, complementarity and synchronicity. Excellence policies influence these relationships through grant conditions, the review process, and the forms and properties of funded projects. Excellence policies usually focus on competitive relationships: they establish or strengthen competition by challenging researchers or organisations to write the most attractive and convincing proposals. In addition, excellence policies sometimes strengthen collaborative relationships too, in the case they allocate funding to teams, consortia or networks of researchers. A third common relationship to generate excellent performance is similarity, in the case of funding instruments aiming to create critical mass on a limited number of specific research themes.

Our main question is what policy instruments have the strongest potential to achieve differentiation in terms of resources and performance. This question calls for an answer to two specific questions. First, which of the four instruments has the strongest effects in terms of differentiation? Second, is there a relation between the effect of a policy on differentiation and the key characteristics of its coordination approach, in particular its intervention and the relationships it strengthens?

3. Methods and case selection

This paper analyses excellence policies in Denmark, Germany, Switzerland, and the UK. These cases were selected over other possible examples (e.g. France or Spain) for number of reasons.

All four countries make substantial investments to some form of excellence initiative. However each applies its own design according to its national priorities and constraints and there are some differences in the proportion of funds invested on excellence (with Germany and Denmark investing relatively less than Switzerland and the UK, see Table 1). Moreover, the cases present a mix of funding modalities (ex-ante vs. ex post; part of the regular funding cycle vs. a 'top up'). For instance, Auranen & Nieminen (2010) find that Germany and Denmark have input-oriented core funding and a small share of external funding whereas the UK has output-oriented core funding and a high share of external funding.

The four countries are all good performers in research and innovation. All four are within the top-10 European Innovation scoreboard[1]. They are all are high-income countries, they belong to the most advanced science systems in the world and spend considerable amounts of public money on R&D. They perform strongly in science and innovation rankings (as shown in Table 2). Collectively, they account for about 30% of the universities in the top-100 of the 2016 Times Higher Education university ranking and for a quarter in the top-100 of the 2015 Centre for Science and Technology Studies (CWTS) Leiden Ranking. Their size, diversity, and relative performance provide significant leeway for being selective and increasing internal differentiation. However, there are some notable differences. Denmark, Germany and Switzerland have high comparative levels of R&D investment and have increased their investments (from ca 2.5% to ca 3% of Gross Domestic Product (GDP) in 2015 – see RIO reports), whereas the UK's expenditure on R&D as a percentage of GDP is relatively low and has remained stable (1.7% in 2007 up until 2015). Moreover, between 2007 and 2012, Switzerland, Denmark, and the UK have remained strong contenders or have made considerable gains. Germany, on the other hand, remained relatively stable or deteriorated in performance. For example, although differences are statistically not very significant, it is still interesting using the RECI indicators for the EU, to note that Germany fell in ranking in the share of highly cited publications in total publication, in the number of top universities and public research organisations per unit of Gross Expenditure on Research and Development (GERD), and in the overall RECI score, while the UK and Denmark grew.

While similar in performance, each country pursues excellence within its own specific (policy) context. The countries differ in the organisation of their science systems and in their approach to, and interpretation of, 'excellence' and differentiation. Denmark is trying to prioritise research excellence in a small open economy, where strategic research funding should go to bring most value added in terms of innovation output and link to a European research agenda. This country has, thus, a very strong focus on the value added measured in innovation output. Denmark also shows clearly how excellence funding is embedded in the broader policy picture – as part of broad reforms, a process of mergers was initiated and a bibliometrics indicator to reward research performance has been introduced. Germany is unique because of its Excellence Initiative, which was a direct response to global threats (particularly the 2003 Shanghai ranking where Germany fared poorly). Two features make Germany interesting, i.e. (a) a taboo holding that all HEIs are equal was broken, and (b) this initiative provides *extra* funding rather than reallocating existing resources. In this sense, the Excellence Initiative is not just embedded but affects the overarching policy mix. Several other countries reacted to the so-called 'Shanghai shock' with their own 'excellence initiatives. For example, France

[1] http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards

initiated its 'Plan d'Investissement pour l'avenir' ('Plan for Investment in the Future'), which also supported the development of a number of larger higher education and research institutions (called 'Poles' of research and higher education - PRES) as well as Plan Campus, aimed at physical refurbishment of institutions (Boudard & Westerheijden, 2017). Spain, too, implemented its 'excellence initiative' in the form of the 'International Campus of Excellence' (CEI), which would (*inter alia*) reduce fragmentation and improve the visibility and reputation of Spanish universities in global rankings (Seeber, 2017). However, unlike France or Spain, Germany (and the other cases analysed in this paper) did not seek to address significant and longstanding weaknesses in the system such as infrastructural problems. Instead, the focus was to promote more stratification within what was considered an already successful system. Switzerland was chosen because it focuses strongly on the framework (governance) conditions. The NCCRs described in this paper are networks in specific fields/topics and are meant to promote institutional competition, research excellence, and reinforce the university landscape and management. Finally, the UK has a long history of selective research funding. The REF is formula-based model to inform the selective allocation (*ex post*) of research funds to universities. The UK is an interesting case to set side by side with the others because, arguably, it has no 'excellence initiative' as such. The REF (and its predecessors) is not an ad hoc and time-limited scheme but has been part and parcel of the country's research policy for several decades. Yet, the introduction of a competitive allocation model (of existing fuds) was a response to new challenges. It was primarily intended to maintain excellence by preventing spreading out resources throughout the whole system after polytechnics were upgraded to university status in 1992. Indeed, to maintain and pursue differentiation, over the decades the government has changed the weights in the funding allocations to concentrate resources in top scoring departments. Hence, while it is not 'ad hoc' like other initiatives presented here, nonetheless, 'ad hoc changes' have been made within the framework to support stratification.

Hence, we use a number of indicators to select the best cases, including the RECI, the CWTS Leiden Ranking and the national expenditures on R&D as percentage of GDP, as presented in Table 2.

The RECI indicators compare the countries' research performance. They are well-accepted since they are comprehensive and take into account different dimensions of research performance, including the context, knowledge production (impact) and institutional arrangements (Vertesy & Tarantola 2012). We use the CWTS ranking as a proxy to gauge system research performance because, unlike other rankings, it does not rely on subjective data obtained from reputational surveys or on data provided by universities themselves. Instead, the CWTS ranking it is entirely based bibliometric indicators. Although it covers universities only, it is still a proxy for the performance of the system. At the same time, because it covers partial elements, we also use the other (fuller) indicators such as the R&D as % of GDP. Together, these indicators have sufficient explanatory power to enable informative cross-country comparisons.

Table 1 presents a comparison of the excellence initiatives' relative importance vis-à-vis their national research policy landscape. For consistency, we compared the investments in excellence (as defined in this paper[2]) to the GERD data for each country. Moreover, the table indicates, albeit in very synthetic way, the key other policies which impact on excellence in research.

[2] Note: the table counts only the investments presented in the cases. For example in Denmark the DNRF focuses on a number of 'elite programmes' (see below), but the paper looks specifically at the CoE investments and thus the table accounts for the CoE budget as opposed to the full DNRF budget

Table 1. Relative importance of excellence initiatives in four countries, and policy context

	GERD	Excellence investment as % of GERD (in a given year)	Other relevant policy examples to promote excellence
Denmark [a)]	€7.6bn	1%	2003: University Act to stimulate institutional profiling; Mergers
Germany [b)]	€80bn	1%	Reform in the Federal-Laender relationships to fund research and innovation; support for non-university research, etc.
Switzerland [c)]	€15bn	3%	Policy reforms of governance and organizational structure of the system e.g. the Higher Education Coordination and Funding Act (2015) to overcome fragmentation between different domains of the Swiss higher education sector and between the Confederation and the Cantons; merging of State Secretariat for Education and Research and the Office for Professional Education and Technology; creation of the Swiss Innovation Park to promote innovative companies in Switzerland
UK [d)]	€36.5bn	3%	The 2011 Innovation and Research Strategy for Growth (IRS) published by BIS encompasses research, innovation and education aspects, and proposes investment decisions for research infrastructures; the UK Industrial Strategy including ten Sectoral Strategies also formed a basis for strategic planning.

[a)] Benchmark year: 2012; (source: RIO report)
[b)] Average GERD based on data 2012-2015; average Excellence Initiative per year (€4.6bn over 10 years) (source: RIO report)
[c)] GERD 2012 (last recorded year in RIO report); average NCCR investment per year (€2.14bn over four years) (source: RIO report)
[d)] GERD 2015 (Source: UK office of national Statistics[3]); REF (quality-related element) was €1.24bn in 2016

By using the heuristic framework on coordination we can compare the cases systematically. We contend that the mix of similarity in performance and specificity in national policy across the selected cases provides a comprehensive picture and is, thus, a fruitful way to draw some generalizable conclusions.

[3] https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgrossdomesticexpenditureonresearchanddevelopment/2015

Table 2. National performance in the Research Excellence Composite Indicator Scores and the CWTS Leiden Ranking compared with R&D expenditure, c. 2007 and c. 2012

	Research Excellence Composite Indicator		CWTS Leiden Ranking [a)]		R&D as a percentage of GDP (%)	
	2007	2012	2006-2009	2010-2013	2007	2012
Denmark	3	2	5	7	2.5	3.0
Germany	5	8	9	10	2.4	2.9
Switzerland	---	---	1	1	2.7 [b)]	3.0
UK	7	5	4	3	1.7	1.7

[a)] Ranking of national average Mean Normalised Citation Scores of universities included in the ranking.
[b)] 2008.
Source: EC-JRC European Commission Joint Research Centre, Research and Innovation Observatory (retrieved April 28, 2016). CWTS Leiden Ranking 2015. R&D as a percentage of GDP from OECD MSTI.

The data presented here are derived from secondary sources, including scientific literature and policy reports (e.g. national science and innovation evaluation reports), international comparative studies (e.g. by the OECD), project reports, and policy briefs. Desk research of these sources has been complemented by interviews with 14 country experts.[4] Our heuristic framework enables a systematic comparison of the four policy instruments, combining information on rationales, contexts, designs, implementation, as well as details on selection criteria and evaluation procedures.

The paper examines each policy's impacts on differentiation in the science system. Because of the study's reliance on secondary sources, we have used both quantitative information (e.g. bibliometric trends or changes in ranking positions) and a subjective assessment of the policy's effects (e.g. on institutional strategic choices and recruitment policies).

4. Excellence policies in four countries

To provide a coherent narrative this section first provides a brief description of each policy in its national context, interpreted under the prism of its coordinating mechanisms.

Denmark: the DNRF Centres of Excellence

In general, Denmark fares well in research performance. It is among a group of four innovation leader countries, ranked third on the European Union's (EU) 'Innovation Union Scoreboard 2015' (European Commission, 2015), with an impressive publications impact according to data from the Ministry of Science, Innovation and Higher Education (MSIHE, 2013). Over the years, Denmark's GERD has remained over 3% of GDP. Between 2012 and 2014 the GERD grew from about €7.6bn to over €7.95bn (Grimpe & Mitchell, 2016, p.12).

The DNRF was established in 1993 and focuses on elite programmes. There are several funders in the Danish landscape of research funding, but the DNRF is the coordinating actor when it comes to funding excellence. The CoE programme is the DNRF's primary funding mechanism and the foundation's flagship since 1993 (DNRF Website, 2016). According to the Ministry's evaluation (MSIHE, 2013, p. 19) the CoE programme covers over 80% of the DNRF's research activities. Using 2012 as a bench year, the total 2012 DNRF budget was €52m, which means that investments in excellence were approximately 22% of overall

[4] Germany: Dagmar Simon, Stefan Hornbostel, Frank Ziegele and Jochen Gläser; Switzerland: Benedetto Lepori, Dietmar Braun and Antonio Loprieno; Denmark: Thomas Trøst Hansen, Evanthia Kalpazidou Schmidt and Kaare Aagaard; UK: Jeroen Huisman, Maria Nedeva, Ben Martin, and David Sweeney

investments in R&D and specifically supporting CoEs were 18% (MSIHE, 2013. p.17). To date, DNRF has funded about 100 CoEs. The total funding of current CoEs amounts to over €370m.

CoEs are collaborative research units based at research institutions (primarily universities), led by outstanding researchers, and oriented towards producing ground-breaking results within and across scientific fields. Partnerships may include researchers of different institutions, either domestically or internationally. The endowment is divided into two periods of six and four years. The application process follows two stages. First, prospective CoE leaders submit letters of interest with short proposal outlines. A recent addition to the scoring system is the 'P-score', (for 'Potential'), which rewards proposals that might deliver ground-breaking results despite high risk (MSIHE, 2013). In the second stage, full applications are peer reviewed in an open competition where funds are not pre-allocated to priority areas or disciplines. Peer review criteria call for (i) an ambitious and original research idea with potential for real scientific breakthroughs, (ii) centre leader with high standing in the international research community, (iii) a team that can establish a creative and dynamic international research environment, and (iv) a degree of focus, structure, and size that set the stage for scientific ventures that are not feasible within conventional funding from other sources. Next, the Board interviews the CoEs' intended principal investigators prior to making a final decision.

The key goals underlying the establishment of the DNRF and the introduction of the CoE programme included boosting the competitiveness of Danish research, prioritising certain fields of study, internationalising Danish research, concentrating funds and supporting university excellence (interview data). Compared to other instruments, CoE funding is long-term (up to 10 years) (Schneider & Costas, 2013). The last 10-year CoEs were meant to be established in 2016/17 with the DNRF's funding ending in 2026 (MSIHE, 2013). However, as a follow-up on the 2013 evaluation, the government refunded the DNRF with over €400m and the foundation will now start another round of CoEs in 2026 (interview data). The CoE scheme was designed to reward individuals, particularly (MSIHE, 2013; OECD, 2014). There are no specific organisational structural requirements nor fixed formulae for creating a centre (Langfeldt *et al*., 2013). Only the so-called 'Investment Capital for University Research' (UNIK) initiative, which was implemented from 2009 to 2013 was strictly university-based (OECD, 2014; European Commission 2016). Funding allocation is determined by the competitive *ex ante* assessment of proposals in two stages described above[5]. CoEs are monitored and evaluated throughout the funding cycle through midterm and end-term evaluations which assess, *inter alia*, the research achievements and the management of the centre. To date, the success rate (from outlines to final approval) has been approximately 6% (MSIHE, 2013), leading to almost 100 CoEs.

As in the other cases, the Danish CoE scheme is part of broader reforms of science system. Denmark has undergone a number of significant reforms, including *inter alia* the 2003 University Act, which stimulated institutional profiling and collaboration between the actors of the research and innovation system and justified a subsequent far-reaching merger process (Aagaard & Mejlgaard 2012; Öquist & Benner 2012; Kalpazidou Schmidt 2012; European Commission, 2016; interview data; Aagaard 2011; Aagaard *et al*, 2016).

Table 3

Coordinating aspect	Description
The coordinating actor	DNRF
The system addressed	National science system
The activities subject to coordination	The scheme is designed to reward individuals, in particular CoE leaders. The DNRF strives to reward curiosity-driven applications (an exception is UNIK, which ran

[5] http://dg.dk/en/centers-of-excellence-2/assessment-and-selection-of-applications

	from 2009 to 2013 and had as goal to strengthen the central steering capacity of universities)
The interventions taken	Funding collaborative research units (CoEs) oriented towards producing ground-breaking results and established within and across scientific fields
Types of relationships that are established or strengthened	Competition and collaboration: competition is strengthened through the selection process, but CoEs are collaborative research units whose partners may be from different institutions, nationally or internationally. Moreover, there is no prescribed organisational structure and most CoEs are cross-disciplinary. Following the selection, the DNRF and the CoE leader initiate negotiations with the host institution on co-financing, facilities, and the centre's sustainability after the DNFR support ends.

Germany: the Excellence Initiative

Germany is a federal state with multiple layers of authority and different funding flows, both at federal and state levels. At the federal level, the main responsibility for research policy lies with the Federal Ministry of Education and Research , which provides about 58% of the federal R&D resources (mostly distributed through the DFG, Dialogic, 2014, p. 82 ff.). At the State level the ministry of Science and Education and the ministry of Economics are the main players (Dialogic 2014, p. 82 ff.). Overall, Germany spends almost 3% of GDP on R&D. According to the RIO Country Report 2015 (Sofka and Sprutacz, 2016), as of 2014 the GERD was €83.9bn (2.87% of GDP).

The German 'Excellence Initiative' was launched in 2006. This initiative is expressly a response to increased international competition and, specifically, the need to support the country's global higher education position in the wake of the first global league tables that appeared in 2003 (Jiao Tong University's Academic Rankings of World Universities). It provides top universities about €4.6 billion in additional funding over two phases (2006-2011 and 2012-2017). Therefore, the full initiative (over 10 years) amounts to less than 6% of one single year's GERD. It is therefore marginal (e.g. compared to Denmark) but its specificity is that this is an addition to existing funds (i.e. a new budget line).

The Excellence Initiative's aim is to increase differentiation in the system, improve research performance and improve international attractiveness of German research. Many researchers see this initiative as unique because it distributes extra money unlike other programmes that merely reallocate existing funds. It is indicative of Germany's endeavour to implement a funding modality that boosts excellent research production. The Excellence Initiative is based on a competition that follows a two-stage review procedure, and which is not managed directly by the federal and state governments. Instead, the process is managed by a collaborative implementation group that includes the German Research Council and the German Science Council. The initiative was scheduled to end in 2017 but on June 16th 2016, the federal government and the states agreed to establish a follow-up initiative (the 'Excellence Strategy'), taking into account the results of the evaluation (e.g. Klumpp, de Boer & Vossensteyn 2014).

The three areas that can be funded include:[6]

- Clusters of excellence: they should, *inter alia*, '[…] enable German university locations to establish internationally visible, competitive research and training facilities, thereby enhancing scientific networking and cooperation among the participating institutions', and should ' […] form an important part of a university's strategic and thematic

[6] The application in all three lines has to go through leadership. Therefore, there is always an institutional strategic orientation

planning'[7]. This track does not support whole universities but certain groups within one or more units;

- Graduate schools: are meant to promote early career researchers: a university with a good graduate school may apply for funding (this track has been removed from the forthcoming 'Excellence Strategy');
- Institutional strategies ('Zukunftskonzepte'): aim to promote top-level research in Germany and increase its competitiveness at an international level. This track supports entire universities and covers all measures that allow universities to develop and expand their areas of international excellence over the long term and to establish themselves as leading institutions in international competition.

The initiative provides universities with additional funding. In its first phase it granted over €2bn in funding to 37 universities in three funding lines, but only the nine universities in the highest of the three categories ('Institutional Strategies' (Zukunftskonzepte)) were labelled 'elite universities'. During the second phase (launched in 2009) the core principle was to engender competition between new projects and those already receiving funding. Successful draft proposals for new projects compete with projects that funded during the first phase and that could submit 'extension proposals'. In the second phase, 30% of winners were new proposals while 70% were existing projects. Overall, 851 draft proposals have been submitted in total, 241 passed the first stage of the evaluation and 114 projects were ultimately funded (13% of draft proposals).

In Germany, too, the excellence initiative fits within a broader agenda for reform of the research system. Although initiatives often do involve financial arrangements, they are part of important policy and legislative arrangements. For example, a constitutional reform was needed to allow the Federal Government to negotiate agreements with individual Laender governments and fund research and innovation in higher education permanently; changes have also been approved to support non-university research (Sofka & Sprutacz 2016). In general, the nature of the Excellence Initiative as a 'top-up' in addition to overarching reforms and a tradition of research support means that, unlike e.g. the REF described later, in Germany research can be conducted well also outside the Excellence Initiative. The key role of the Excellence Initiative is, in fact, to promote prestige and vertical differentiation in the system rather than to allocate research funds across the system.

Table 4

Coordinating aspect	Description
The coordinating actor	The federal and state governments (review process delegated to the external implementation group)
The system addressed	The national university system. Its components target entire universities (Institutional Strategies), groups within one or more institutions (via Clusters of Excellence), and early career researchers (via Graduate Schools)
The activities subject to coordination	Research activities but also some PhD training and promotion (communication).The 'graduate school pillar' will be discontinued in the new 'Excellence Strategy',
The interventions taken	Additional funding for universities (only).
Types of relationships that are established or strengthened	Competition over collaboration: the Excellence Initiative is based on a competition between universities to reward outstanding projects in three areas, namely (i) clusters of excellence, (ii) graduate schools, and (iii) institutional strategies. The clusters of excellence may include inter-institutional collaboration.

Switzerland: National Centres of Competence in Research (NCCR)

[7] See: http://www.dfg.de/en/research_funding/programmes/excellence_initiative/clusters_excellence/

Switzerland is an outlier compared to the other cases presented in this paper. The country's availability of funds and consensual policymaking do not make strong competition and promoting individual excellence really necessary. And a key feature of the funding system of Swiss research is a clear-cut division between the public and private sectors with a dominant role for the latter. Private R&D activities are almost entirely financed by the companies themselves. In general Switzerland is a top-ranking investor in research and development as a percentage of GDP (2.96% in 2012 in total, of which roughly a third is public expenditure). Large shares of funding go primarily to the universities themselves, either through federal funding for the two federal universities or with the regions as primary funders. External funding is predominantly through the SNSF, mainly as an add-on through project support (Öquist and Benner, 2012). Direct funding and the coordination of research activities remains the Federal Government's responsibility, through a number of bodies in charge of allocating public funds such as the State Secretariat for Education, Research and Technology, the Council of the Federal Institutes of Technology, and the Swiss National Science Foundation (a private foundation whose tasks are defined by the national research act and which is almost completely funded by the federal state) (Lepori *et al*. 2016).

In 2000, the Swiss government established National Centres of Competence in Research (NCCRs), which are networks in specific fields or around specific topics. The NCCR scheme has four overarching objectives (Benninghoff & Braun, 2010; CSSI, 2015, p. 8), namely (i) to foster institutional competition, division of labour and collaboration among universities; (ii) to support excellence in research, in particular with the aim of bolstering Switzerland's international position in new fields considered to be strategic; (iii) to contribute to structural reinforcement of the university landscape, favouring long-term institutional anchoring of scientific excellence; and (iv) to systematically encourage more sectorial objectives deemed important for Swiss research excellence such as knowledge and technology transfer, support for young researchers (essentially PhD students), and promotion of equal opportunities.

However, the Ministry has no say in the presentation of topics. The scheme is open to all research fields and provides a means of obtaining long-term investments for consortia for researcher-driven ideas. Submissions are made in response to calls for new NCCRs. They are evaluated by international peer committees and the SNSF in a multi-stage procedure, which includes a pre-proposal and a proposal (SNSF, 2016). A review of pre-proposals involves a scientific evaluation by experts and a structural evaluation by the Programmes division of the Research Council, which evaluates (i) the necessity of restructuring the chosen research field; (ii) knowledge and technology transfer as well as the advancement of young researchers and women researchers; (iii) suitability of the home institution and structural measures planned by the home institution; (iv) delineation and novelty of the topic and the structural goals compared to previous NCCRs in the same field. The proposals are evaluated based on a broad set of scientific and organisational criteria, including the scientific quality of the entire research plan and of individual projects; the added value of the NCCR and its potential for stimulating interdisciplinary research, new scientific approaches and methods within disciplines, and collaboration in new research fields; the support of the home institutions; and activities in the area of knowledge and technology transfer, advancement of young researchers and women researchers. Finally, the State Secretariat for Education, Research and Technology (SERI) evaluates the proposals with regard to research and higher education policies and the Federal Department of Economic Affairs, Education and Research (EAER) has the last word in deciding which NCCRs are to be established, and defines the budget for each. The final decision is strongly based on sustainability criteria, including the significance of the research

field in the strategic planning of the home institution and the regional and national distribution of competence centres.

The programme is run by the SNSF, which receives extra money from the Ministry for this. The total budget of the initiative is about €2.14bn over a four year period. Hence, also in the case of Switzerland it is an addition to the regular funding mechanisms (as opposed to an allocation modality of existing funding). On average, the NCCR scheme thus represents approximately 3% of the country's GERD (€15.36bn in GERD in 2015, see Lepori *et al* 2016). As of 2014, 63 draft proposals had been submitted, leading to 23 full proposals and eight funded. NCCR funding is based on co-financing. On average, SNSF has funded €3.26m per NCCR per year, while home institutions contributed €1.39m per NCCR per year. Of the funding for the first fourteen NCCRs 30% was provided by SNSF, 15% by home institutions, 42% by network partners and partner universities, and 13% by third parties (SNSF, 2016, p.26).

Table 5

Coordinating aspect	Description
The coordinating actor	Swiss federal government; SNSF
The system addressed	Universities
The activities subject to coordination	Research activities: NCCRs favoured greater autonomy in the design and execution of projects (CSSI, 2015). An important rationale was to empower rectorates to prioritise. Researchers must seek support from the rectorate and the rectorate must decide what proposals to submit.
The interventions taken	Funding of NCCRs through a competitive multi-stage selection process including The SNSF receives extra money to run the programme.
Types of relationships that are established or strengthened	Collaboration over competition. The NCCR scheme supports researcher-driven ideas but funds the network as a whole.

United Kingdom: the Research Excellence Framework

The UK research system is largely centralised, although regional autonomy for innovation policy has been increased in recent years (Cunningham, 2015). The public funding system is 'dual', including (a) institutional block funding and (b) project grants from the research councils. The UK was the first country in Europe to introduce formula-based funding for research (as opposed to funding allocated on a historical basis). The Research Assessment Exercise (RAE) began in 1986[8] to periodically measure the quality of research conducted by UK universities. Subsequent exercises were held in 1989, 1992, 2001, 2008, and 2014. In 2014 it was replaced by the REF, which places more emphasis on the societal (non-academic) impact of research. The four higher education funding bodies (for England, Wales, Scotland and Northern Ireland) use the assessment outcomes to inform the selective allocation of their grant for research to the institutions which they fund. Hence, the REF effectively builds competition among universities (Geuna and Piolatto 2016; Dialogic 2014, p. 13; Minelli *et al*. 2015) and rewards past performance on the assumption that it predicts future success[9]. In this sense, the REF is very much part of the research policy system, rather than a 'special' initiative. The REF covers 36 Units of Analysis, namely specialist areas organised by subject, which institutions can choose to enter or not. The last REF included 1,911 submissions by 154 universities (Farla & Simmonds, 2015; REF website).

[8] Under the name 'Research Selectivity Exercise'

[9] See also a critical article by Giosuè Baggio on the: 'Universities need a REF that rewards potential'. At: https://www.timeshighereducation.com/comment/universities-need-a-research-excellence-framework-that-rewards-potential

The REF involves a systematic evaluation process, carried out by peer panels, the results of which directly influence the allocation of block funding. The REF uses three specific criteria, namely (a) the quality of research outputs (65% of the total score), (b) the wider impact of research (20%) and (c) the sustainability and vitality of the research environment (15%) (Manville *et al*. 2015; Farla and Simmonds, 2015). As part of the evaluation (2008-2013), institutions must provide the required information on staff to be included in the submission, including (a) details of publications and other forms of assessable output produced during the publication period (up to four outputs for each member of staff); (b) a description of the submitted unit's approach to enabling impact from its research and case studies describing specific examples of impacts achieved; (c) data about research doctoral degrees awarded and research income; and (d) a description of the research environment.[10]

The REF is unlike the other three policies in that it evaluates performance *ex post* rather than *ex ante*. HEFCE grants for 2016-17 total €4.27bn; 43%, are for research and, of this amount, 68% (€1.24bn) was allocated based on REF results. According to the UK RIO 2015 report, the GERD was €34bn, of which 28% (€9.52b n) were public funds. The quality-related (QR) element, which depends on the REF, is about 3% of the UK's GERD. The 2016-17 available budget dropped by 7% from the previous year. However, the research budget increased by 1% and the quality-related (QR) element increased by 5%[11]. The REF as well as its precursor are good examples of ways to concentrate resources for research in a relatively small number of universities (see e.g. Barker 2007; Jongbloed *et al*. 2015; de Boer *et al*. 2015; REF website).

Table 6

Coordinating aspect	Description
The coordinating actor	The four higher education funding bodies for England, Scotland, Wales and Northern Ireland; managed by the REF team based at HEFCE on behalf of these bodies, and overseen by a steering group of representatives from these bodies.
The system addressed	National university system, on the level of research units.
The activities subject to coordination	Research activities. The REF's primary purpose is to inform the allocation of quality-related research funding (UK government, 2016).
The interventions taken	A systematic evaluation process carried out by peer panels against three criteria (quality of research outputs, impact, and the sustainability and vitality of the research environment). Institutions must also provide information about their staff (e.g. such as publications and doctoral degrees). The evaluation outcome determines the allocation of institutional block funding.
Types of relationships that are established or strengthened	Competition among providers.

5. Comparative analysis

Our concern in this paper is primarily whether and to what extent excellence policies in science affect the institutional differentiation of resources and performance. Excellence initiatives have common features but they are always tailored to national contexts. Therefore, they differ significantly from one another in their design and understanding of success. Furthermore,

[10] See: http://www.ref.ac.uk/media/ref/content/pub/assessmentframeworkandguidanceonsubmissions/GOS%20including%20addendum.pdf

[11] See: http://www.hefce.ac.uk/funding/annallocns/1516/; http://www.hefce.ac.uk/funding/annallocns/1516/research/; http://www.hefce.ac.uk/funding/annallocns/1617/: http://www.hefce.ac.uk/funding/annallocns/1617/

changes in performance and differentiation within a system always emerge from a mix of policies and factors. Governments of the four countries investigated in this paper all felt that the pursuit of 'excellence' was necessary to promote the science system, and that resource concentration and vertical differentiation could facilitate the achievement of this objective. However, there are considerable differences between the four excellence policies. Moreover, the nature, quality and relevance of available studies about their effects varies. In this section, we compare the policies using Hessels' heuristic framework for coordination and, based on the evidence presented thus far, evaluate their effects on differentiation.

5.1. Comparing coordination approaches

Table 7 compares the aspects of coordination that were identified in the four excellence policies using our heuristic framework. The first observation is that all policies are aimed at institutions rather than individuals, and all use funding as their instrument for intervention. The four policies show that there is an understanding that institutional performance is related to individual performance. So, for example, the Excellence Initiative funds graduate schools, which develop individual researchers.

The second observation is that the excellence policies vary in terms of the relationships they establish or strengthen with their coordination approach. We can distinguish between the Excellence Initiative and the REF that create competitive relationships and the DNRF CoEs and NCCR, which also form collaborations, look for complementarities, and – in Switzerland – create critical mass. The mechanism of the 'competitive' Excellence Initiative and REF is to fund the best institutions as a way to raise future performance. The less competitive DNRF CoE and NCCR – here denoted as 'non-competitive' – work by investing in capacity for excellent research in the long run (attracting talented researchers in Denmark; supporting the sustainability of NCCR beyond programme funding in Switzerland). The activities in the 'competitive' excellence policies are geared towards reinforcing differences among institutions (greater vertical differentiation and an allocation of QR funding biased towards the top performers). The activities in the 'non-competitive' policies aim to empower institutions and individuals; they work bottom-up or are researcher-driven.

Table 7. Aspects of coordination per excellence policy

		Excellence policy			
Aspects of coordination		***DNRF Centres of Excellence***	***Excellence Initiative***	***National Centres of Competence in Research***	***Research Excellence Framework***
	Country	Denmark	Germany	Switzerland	UK
	Coordinator	DNRF	federal and state governments	federal government; SNSF	HE funding bodies
	System	national science system	universities	universities	universities
	Activities	Research	Research, PhD training and communication	Research	Research
	Intervention	long-term grants for CoEs; duration of grants is 10 years(first 6, then 4)	additional funding with bias towards established projects; duration of grants is 10	funding for NCCRs; duration of grants is 12 years	block grants depend on REF results; RAE/REF have been held about every 6 to 7 years

		years in two 5-year phases		
Relationships	competition and collaboration (interuniversity, interdisciplinary), complementarity	competition (and collaboration)	similarity (critical mass), collaboration (network of partner institutions), complementarity (research groups working across disciplines)	competition

5.2. Effects on differentiation

While each scheme is unique and integral to its own system, one can cluster different effects of policy on institutional differentiation. Three broad trends appear to be common to all cases. However, to understand these findings the reader is urged to consider two important aspects. First, the effects differ in their measurability and impact. For example, an evaluation of the Swiss NCCRs emphasised that participating in a NCCR does not *weaken* researchers' competitiveness in their application for ERC funding[12]; a similar argument can be made regarding the success in DFG funding for institutions included or not in the Excellence Initiative (DFG, 2012, p.76). Second, this research looks at differentiation *within* the system. The cases have shown that the policies often have aggregate effects (e.g. an increase in the national aggregate volume of highly cited publications); but that goes beyond the specific question this article addresses.

The broad 'differentiation trends' include:

1) publication performance: the different excellence initiatives appear to have some effect on publication output, impact and citation indexes. In general, gaps in performance – measured for example by bibliometric means – appear to increase as a result of the policies;
2) research awards beyond the excellence initiative: the policies appear to have a marginal impact on the success of different institutions on winning other awards, above and beyond the specific excellence endowments;
3) no policy appears to *generate* differentiation. Instead all policies expose pre-existing and at times latent diversity in the system. This is clear, for example, in Germany and Denmark.

These trends play out slightly differently in each country, as shown below.

DNRF Centres of Excellence (Denmark)

Schneider and Costas (2013) show that, between 1993 and 2011, the share of DNRF publications in journals indexed by Thomson Reuters Web of Science increased faster than that of non-DNRF publications; the number of non-DNRF publications increased by about 97% compared to over 1,000% for DNRF publications (from 0.5% to 10.8% of total Danish output).

[12] Original text (CSSI, 2015, p. 24): 'Une analyse exploratoire tend à confirmer que, pour des chercheurs actifs en Suisse, la participation à un PRN n'affaiblit pas la compétitivité'

Moreover, DNRF publications outscore non-DNRF publications in all impact indicators and the difference in impact is consistent over time.

The trends over time show that changes in institutional performances tend to go in the same direction. This suggests that the CoE programme perpetuates a pre-existing differentiation within the system rather than generating it. The programme did not aim explicitly at increasing vertical diversity. It was meant to strengthen the research environment generally. However, as part of a coherent policy mix which included, *inter alia*, university mergers, stronger differentiation ensued (interview data). A limited number of stronger performers (University of Copenhagen, Aarhus University and the Technical University of Denmark) effectively produce two-thirds of public research in Denmark (European Commission, 2016; interview data).

Excellence Initiative (Germany)

An independent international panel of experts (*Internationale Expertenkommission Exzellenzinitiative*, or IEKE) recently evaluated the Excellence Initiative, highlighting a number of effects and providing recommendations for the future (IEKE, 2016).[13]

Bibliometric data suggest an increasing gap in publications between universities that are part of an Excellence Initiative cluster and those that are not (IEKE, 2016). Between 2008 and 2011, Clusters of Excellence had a higher proportion of highly cited publications (top-10%) than non-Excellence Initiative universities (IEKE, 2016, p. 19; Hornbostel and Möller, 2015, p.48). Over time, the proportion of highly cited publications of non-Excellence Initiative universities remained relatively stable, whereas that of Excellence Initiative universities increased. Universities with an Institutional Strategy ('ZUK-unis') appear the strongest performers, though they started off from a stronger position.[14]

There are indications that the Excellence Initiative has exposed and reinforced existing differentiation among universities. The German university system has always been divided between stronger and weaker research institutions. The Excellence Initiative appears to redefine 'old top universities' as 'new top universities' (see also Hornbostel and Möller, 2015, p. 52; Kehm & Pasternack 2009; Kehm, 2012). The public debate ensuing from the Excellence Initiative has highlighted marked differences in research performance across German universities and has ended the idea that 'all are equal'. The Science Council (*Wissenschaftsrat*) links this exposure to the introduction of research assessment instruments (Wissenschaftsrat, 2011, p.15):

> 'Whereas performance differences that existed were previously known for the most part only to an initiated specialist community, an explicit clarification of the respective concept of quality in research became necessary in the process of developing assessment methods.'

The Excellence Initiative has led to a number of reactions and alternative initiatives. For example, the Rectors' Conference is seen as 'the voice of universities'. However, shortly after the Excellence Initiative was established new (informal) groups were formed, such as the 'U-15' or the 'TU-9', purporting to represent Germany's 'top institutions'. This is a new trend in Germany, which some see as a threat to inter-institutional solidarity within the system, while

[13] The report also emphasises that the results are largely based on examples rather than a comprehensive empirical examination of the effects on the system's vertical differentiation.

[14] Institutional Strategies can only be granted if the university was also successful in attracting at least one graduate school and at least one cluster of excellence. Leading universities with an Institutional Strategy can receive to a €20 million per annum for excellence (See Hornbostel and Möller 2015, p. 31)

it can also be seen as a reproduction of concepts such as the British 'Russell Group' (interview data).

It is uncertain whether the stratification of the German university and research system triggered by the Excellence Initiative will be permanent (Hornbostel and Möller, 2015 pp. 49ff). Contrary to the federal government's original plans, several universities are apparently relying on a continuation of Excellence Initiative funding for support. Other institutions expect that the federal states will cover at least part of the costs to support them.

National Centres of Competence in Research (Switzerland)

There is little information on the effects of NCCRs on differentiation within Switzerland. However, differentiation of funding is an integral part of the country's higher education structure. The Swiss Federal Institutes of Technology domain (*Eidgenössische Technische Hochschule*, or ETH), the cantonal universities and the Universities of Applied Sciences are in principle horizontally differentiated. This differentiation is, however, de facto vertical, also by virtue of funding policies. On the other hand, Switzerland has adhered strongly to a bottom-up approach, with some exceptions to support specific fields, which include the NCCRs (interview data).

The NCCRs seem to have been particularly successful in bringing about an overall concentration of research activities. While the NCCR has features of a CoE scheme, the programme actually supports geographically dispersed constellations and in that sense differs from traditional CoEs (Öquist and Benner, 2012).

The Swiss Council for Science and Innovation (Conseil suisse de la science et de l'innovation; CSSI) has conducted an impact evaluation of the NCCR programme. The analysis focuses on the NCCRs' contribution to structuring the higher education landscape in Switzerland and is based on the completed NCCRs (2001-2013). The CSSI review indicates that (a) there might be a relationship between participating in NCCRs and the number of ERC grants and (b) the NCCR instrument appears to be have become a tool for institutions' strategic planning and profiling.

A successful NCCR may be continued after public funding ends (over a dozen new research centres emerged from the NCCRs). A key purpose of the NCCR scheme was to strengthen central university management. This has proven important for the creation of new centres. Maintaining the existing NCCRs has proven harder as no subsequent funding is expected. The review does point out a 'sustainability risk' in that after the end of the 12-year period – when roles and responsibilities are contractually regulated – network members might not comply with agreements made during the funding period. Moreover, it is clear that the roles of the partners (host and other institutions) will change over time (CSSI, 2015).

Research Excellence Framework (UK)

The REF and RAE reflect differentiation between institutions in the system, even though they are not primarily intended to encourage differentiation (interview data). Excellence was found within institutions with submissions of all sizes, and each element of the assessment – outputs, impact and environment – provided differentiation between institutions.[15]

The RAE/REF system appears to perpetuate existing differentiation among institutions rather than facilitating changes in the rank order of institutions based on their performance.

[15] Three-quarters of the institutions had at least 10% of their submitted activity graded at 4*. One quarter had at least 30% graded at 3* or above, three-quarters of the institutions had at least 49% of their submitted activity graded at 3* or above. One quarter had at least 79% graded at 3* or above. See: http://www.ref.ac.uk/results/analysis/institutionalaverageresults/

Geuna and Piolatto (2016) have analysed the UK research assessment policies since the 1980s. They observe that that government has repeatedly changed the weights in funding allocations in order to maintain the selectiveness of QR funding and concentrate resources in top scoring departments.[16] This increases the premium for being at the top. Geuna and Martin (2003) observed in increase in RAE costs within universities, which are easier to afford for richer universities, thus reinforcing existing inequalities.[17] The RAE/REF system also provides strong incentives for disciplinary (mode-1) research, despite a policy push towards interdisciplinary and transdisciplinary (mode-2) research. This also tends to reinforce existing inequalities.

Institutions can game the REF. They have much leeway in whether they participate, and in what units and staff they present (interview data). This results in grade increases rather than a real improvement in the quality of research (Geuna and Piolatto, 2016). A comparison between the results of REF 2014 and RAE 2008 hints at gaming. On aggregate the REF panels found higher output quality than the RAE during the previous period. The overall number of submissions dropped by 11%. Yet, the absolute number of outputs judged to be 4* and 3* increased. The percentage share of 'world-leading outputs' (4*) and 'internationally excellent outputs' (3*) grew from 51% to 72%. This is why Lord Stern's review of the Research Excellence Framework suggests that institutions should be required to enter all their academics.

The focus on publication numbers may be detrimental to producing real 'breakthrough research' because opening new research lines typically requires strong investments, which in turn means not publishing for some time as a centre is built or innovative findings are produced.

Table 8 summarises the findings on differentiation just presented. The analysis does not reveal clear differences between 'competitive' and 'non-competitive' excellence policies. Moreover, there is scant evidence of effects on differentiation among individuals but all excellence policies make institutional differentiation evident. In each case pre-existing differences exist. At least in Denmark and the UK (and to some extent in Germany) excellence policies seem to reinforce these differences. The latter consideration points to the risk that, if not carefully designed and implemented, government initiatives to concentrate and reward top research might lead to the so-called 'Matthew effect' (Merton 1968; 1988) rather than promoting excellent research. In essence, the 'Matthew effect' describes how the more eminent research performers are, the more likely it is they will continue to be rewarded, regardless of actual quality of proposals or outputs. This means that institutional reputation can turn into a self-fulfilling prophecy as universities or research centres designated as excellent – usually with more resources and more prestige – are *ipso facto* more likely to be selected for funding in any competition. For instance, the experiences of the former polytechnics in the UK show how difficult it is for new performers to become truly competitive.

Table 8. Effects per excellence policy

		Excellence policy			
Effects		***DNRF Centres of Excellence***	***Excellence Initiative***	***National Centres of Competence in Research***	***Research Excellence Framework***
	Country	Denmark	Germany	Switzerland	UK
	Differentiation among institutions	yes	yes	embedded in the Swiss science system	yes

[16] Research Council funding was even more concentrated with 84% going to the top two deciles (Geuna and Piolatto, 2016, p. 264).
[17] The REF costs over £200m (or £4,000 per academic) only to decide how to allocate the money.

	Pre-existing differentiation is important	yes (perpetuate)	yes (expose)	no evidence	yes (perpetuate)
	Promote collaboration	yes		yes	

6. Conclusion and discussion

This paper began with the premise that governments across the world increasingly tend to concentrate public funds in the hands of top science performers through different 'excellence initiatives'. The underlying assumptions are (a) that rewarding the best will promote performance at all levels of the science system and (b) that the benefits for the research community at large outweigh the lost funds for those who are not (yet) deemed 'excellent'. In this paper we systematically compared excellence policies in different countries by using the heuristic framework of coordination and by keeping in mind the specificities and policy coherence of each system. Moreover, we chose a mix of complementary indicators because no one indicator can really cover the full extent of the policy mix. Any policy should be understood in the context of the policy mix wherein it rests (see also de Boer *et al*. 2017, pp.269-287). For example, not only research funding policies are relevant but also those governing the quality of research such as research assessment policies. Hence, existing degrees of competition and resource concentration play a key role in shaping excellence policies, their aims and their designs. From the evidence presented in this paper we can draw a number of conclusions and reflections that partly question these beliefs.

First, countries use very 'different recipes for the same dish'. They all try to produce excellence through differentiation but they do so in different contexts and with instruments that are part of broader policy toolkits. All four policies are aimed at institutions rather than individuals; all use funding as the instrument of intervention; and all generate some form of institutional additionality. The policies presented in this article seem to strengthen (or at least expose) *existing* differentiation in the science system. They do not increase or produce differentiation. Quantitative evidence suggests that the relative performance of institutions does not change as a result of the initiatives (the 'winners' would be so regardless). This finding contradicts the common narrative on excellence policies. Thus, we cannot argue conclusively that one instrument has greater potential to achieve differentiation than another.

Moreover, we observe a distinction between 'competitive' and 'non-competitive' (or less competitive) schemes. The Excellence Initiative and REF belong to the first category because they create competitive relationships among research performers; the DNRF CoE and NCCR programmes belong to the latter, as they invest in capacity for long-term excellent research. However, no clear differences in the nature and size of effects generated emerge between the two kinds of coordination approaches.

Third, this paper provides some insight into the important aspect of differentiation amongst individuals. However, the evidence is scant and unsystematic and cannot lead to generalizable conclusions. Secondary sources such as those used in this paper (e.g. policy documents) do not cover the effects of excellence initiatives on individuals but they do provide some food for thought. The data suggests that these initiative can (a) strengthen individual principal investigators – which may promote differentiation and/or (b) support younger researchers as part of the evaluating criteria – which may reduce inter-generational differences in performance. The Danish CoE scheme is meant to support research based on researchers' own initiatives. Hence, one may assume that individual performance has also been affected. Indeed, a study on excellence initiatives in Nordic countries, which included three Danish

CoEs, compared principal investigators' publication and citation scores before and during the CoE period (Langfeldt *et al*., 2013). The study concluded that, in general, research productivity and impact of the researchers increases as a result of the CoE. In Germany, qualitative information suggest that principal investigators play an important role in the research clusters, giving clusters an incentive to attract 'big names' (interview data). Also, graduate schools support younger researchers (but that the next round will not include a graduate school pillar). In the UK, too, there is little evidence to indicate that the REF reshapes the output profiles of different groups of staff. The REF analysis simply reveals that research outputs by early career researchers and staff with other circumstances were found to be of equal quality to outputs by all staff (about 20% of 4* and over 70% 3*+4*). In Switzerland there is no clear evidence that the NCCR scheme affected individuals, although the overarching policy was meant to strengthen institutional management and enabling rectorates to prioritise (interview data). What this tells us, is that there is a need for a more detailed assessment of policies' effects on individuals. Such a study cannot stem from a methodology like the one used for this paper but would require analysis of primary data sources.

Theoretically, these considerations demonstrate that excellence is a contested concept that is hard to define, identify and measure. Policies that include the term 'excellence' in their name do not inevitably focus on, or yield, excellence. But beyond a theoretical lesson, an important methodological message is that the data clarify why and how systematic comparative analyses should be extended. We have examined four policies in comparable, highly advanced science systems using secondary data and expert interviews. This implies analysing different aims, methods, and data rather than systematically collecting original empirical evidence. Building on Hessels' heuristic framework and on the concepts of additionality (which enabled us to study the available information on coordination mechanisms and pinpoint policy effects), one can develop a comprehensive framework and a set of indicators for a comparative empirical analysis of the effects of excellence policies.

Finally, the conscious goal of this paper was to study effects on *institutional differentiation*, which – we argued – is the key expected effect of excellence initiatives. However, the analysis uncovered that most scientists construe excellence policies as a means to gain funding based on scientific reputation. Therefore, policies targeting individuals are critical in the discourse on excellence in science. On the individual level, excellence policies catalyse the credibility cycle, i.e. they help researchers translate recognition into money (Latour & Woolgar, 1986). From this perspective, an important empirical question is whether, just as they do on the institutional level, excellence initiatives strengthen the 'Matthew effect' at the individual level too (Wang 2014).

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