

Aggregate level research governance effects on particle physics: A comparative analysis

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Abstract

This paper contributes to understanding the effects of research governance on global scientific fields. Using a highly selective comparative analysis of four national governance contexts, we explore how governance arrangements influence the dynamics of global research fields. Our study provides insights into second-level governance effects, moving beyond previous studies focusing primarily on effects on research organizations rooted in national contexts. Rather than study over 100 countries across which our selected CERN-based particle physics global research field operates, we explore *conditions* for changing the dynamics of global research fields and examine *mechanisms* through which change may occur. We predict then minimal effects on the epistemic choices and research practices of members of the four local knowledge networks despite variations in governance arrangements, and hence no second-level effects. We assert a research field's independence from governance depends on its characteristics and the relative importance to researchers of research quality notions. This paper contributes methodologically and has practical implications for policymakers. It suggests governance arrangements affect the epistemic choices and research practices of the local knowledge networks *only when certain conditions are met*. Policymakers should consider the context and characteristics of a field when designing governance arrangements and policy.

Keywords: research governance; performance-based evaluation arrangements; second-level governance effects; transnational research fields; research evaluation mechanisms; scientific fields and research practices.

1. Introduction

This paper aims to advance the understanding and empirics of the effects of research governance on scientific fields. We deploy a current framework to study governance effects on research fields (Nedeva, Tirado and Thomas 2022) and to put forward expectation-building scenarios whereby predictable change from policy can be identifiable. We extend this framework conceptually and empirically by conducting a *highly selective* comparative analysis of the reported behaviour of members of a global research field in CERN-based particle physics based upon four national governance contexts. After developing an analytical typology, these four contexts were deliberately chosen to ensure they capture all key types possible for one specific form of governance, i.e. performance-based research evaluation arrangements (PREAs). This means we can develop analytical categories of governance arrangements and their potential to engender change in a research field *without* needing to study its members in all 100 countries contributing to it. In doing this selective comparative analysis, we are not looking to register and empirically measure change *per se*. Rather we aim to propose and test the *mechanisms* through which change may occur. We also aim to contribute to comprehending second-level governance effects, e.g. governance effects on total research fields. This attempts to tackle a long-standing methodological limitation rooted in specific or isolated national contexts (Thomas et al. 2020) that typically fail to

address effects at a field's 'global' level. Previous studies largely overlook effects beyond those on local members of research organizations (first-level effects).

This approach is mindful that the debates about previous studies of research governance effects on scientific fields in the literature generally unfold along three lines. First, some studies, quantitative and qualitative, investigate governance effects on context-specific research organizations, namely universities and research institutes (Lorenz 2012; Luukkonen and Thomas 2016; Vinkenburg 2017; Luo, Ordóñez-Matamoros and Kuhlmann 2019; Thomas et al. 2020; Strinzal et al. 2021; Kozłowski et al. 2022). Second, other studies extend their research interest to include the effects of governance on the epistemic choices of members of local knowledge communities (Gläser and Laudel 2016; Gläser 2019). Third, methodologically, governance effects studies measure change using survey techniques (Abramo, D'Angelo and Di Costa 2018; Tonta and Akbulut 2020), case study/interview approaches (Luwel 2021), bibliometrics (Aagaard 2015; Aagaard and Schneider 2017; Feenstra and López-Cózar 2022) or by seeking to unpack the (soft) causality mechanisms that may affect organizational, personal and group selections (Whitley 2014; Gläser 2019; Whitley and Gläser 2019; Horta and Santos 2020; Veletanlić and Sá 2020; Åm, Solbu and Sørensen 2021; Falkenberg and Fochler 2022; Gläser et al. 2022; Horta 2022; Ramos-Vielba, Thomas and Aagaard 2022).

Our approach combines elements of these lines by considering how governance affects specific *research quality* selections of field members in research organizations. Additionally we consider that these local members are part of a larger scale (research field) structure. We combine elements of context-specific organizations, epistemic (and broader) choices, and mechanisms for change to occur. We do this because whilst previous studies have provided valuable contributions into what can be seen as *first-level* governance effects on science, these approaches seldom extend beyond the locally-specific conditions for knowledge creation (e.g. research funding, university structures, evaluation practices, and local policy). Hence, they omit *second-level*, aggregate governance effects at the level of transnational, global research fields. Yet we argue that to understand how research governance, as it operates in the real world, may affect the dynamics of science, certain elevating work is necessary to assess the effects of policy at larger scales and to determine when such effects are at all predictable (Thomas et al. 2020).

This shortcoming was initially conceptually addressed in a recent paper (Nedeva, Tirado and Thomas 2022). It proposed a framework to link the characteristics of a specific form of research governance (PREAs) and the properties of research fields—i.e. they are linked through cumulative research quality-related selections made by researchers within research organizations. The current paper empirically extends this initial framework by applying it to examine and compare the conditions for governance effects across not one PREA but multiple PREAs. In short, this paper mobilizes the framework vis-à-vis variance unique to four evaluation settings. Like the previous study's approach, to minimize unnecessary distinctions that may generate compounded effects, it remains important to *keep constant the research field* (in this case, once again a part of CERN-based particle physics) and the *type of research organization* (as in the previous study, still 'top of the pile' universities—i.e. historically renowned places of research excellence, see Paradeise and Thoenig 2015; Thoenig and Paradeise 2016). This is done to ensure the key variations we address come *only* from the PREA characteristics.

Four distinctive PREAs are selected to study in this paper. To reiterate, we aim to offer *optimal variety* to enable a fruitful analytical comparison of governance effects on the research field instead of providing exhaustive descriptive coverage of over 100 national governance arrangements. The PREAs selected capture key variance possible in the governance arrangement structures, considered as four possible PREA types (see Section 3—they are the Danish research evaluation system, the Dutch research evaluation system, the Swedish university-level evaluations, and the UK Research Excellence Framework or REF). Our aim is not simply to register differences across contexts but to comprehend different behaviours and responses regarding the mechanisms prompting effects at the global research field level. In other words, we use a theory-informed scheme to investigate field-level dynamics and aggregate effects resulting from sufficiently varied local PREA-related governance influences, and to predict then test whether and how such effects might appear.

This paper is structured as follows. After briefly presenting the framework, we move on to the analytical dimensions along which PREAs vary, characterizations of the selected PREAs, the research field, and the type of universities, and

our methodology. Following this we present the empirical findings and discuss what they mean for how effects of research governance on total scientific fields can be studied.

2. Framework for the study of governance effects on research fields

The framework brings together two recent conceptual developments. First, it is founded on a framework to study how science involves dynamic interactions between co-existing notions of research quality (Langfeldt et al. 2020). It applies a distinction between Field-type (F-type) and Space-type (S-type) quality notions¹ to interrogate these interactions empirically in the context of critical and cumulative organization-level selection events made by researchers in specific research fields. These selections affect the research field local members, given that they relate to organizational career development, knowledge production and knowledge dissemination. Second, the framework uses a more nuanced understanding of the governance instrument of research evaluation (Thomas et al. 2020). This delineates and focuses solely on evaluation arrangements within research spaces, or PREAs. Figure 1 summarizes the tenets of this framework to study the governance effects of multiple PREAs on scientific fields.

The explanatory value of this framework for tracing governance effects on scientific fields is as follows. First, it acknowledges three contexts where different effects may occur, e.g. the *research space context* where PREAs are embedded, the *research field context* where knowledge claims are assessed to award reputation (e.g. publications, grant capture), and the *context of research organizations* where individual and collective performance are evaluated for organizational career purposes (Thomas et al. 2020). Second, it recognizes that the context of the research organizations is where F-type and S-type research quality notions collide and coexist. Third, it contends that the *interface* between F-type and S-type quality notions can be empirically explored at key organizational selection points, through the interactions between university/institute leaders and members of local knowledge communities. Fourth, it posits that members of local knowledge communities may or may not change their topic and method selection and quality notions depending on who (the community or the organization) has authority over research resources, reputation allocation and the relative value of organizational and field careers (Gläser and Laudel 2015).² These are still *first-level* governance effects. Fifth, whether and what *second-level* governance effects occur depends on the structure and type of the research field, the positioning of the local knowledge community in the research field network, and the *aggregate* of the effects in different PREAs.

This framework was previously tested in one PREA and one research field. This yielded initial evidence that local members in the UK of a specific CERN-based particle physics field seemed largely independent of their PREA's (the REF) influence (Nedeva, Tirado and Thomas 2022). However, without specifying possible mechanisms for influence, and without exploring other PREAs representing other governance forms, there is no reason to believe that local members in other countries/PREA settings, and members of the total field at transnational level in the aggregate, might be similarly independent overall. Therefore, we believe it is necessary to extend the previous study also to interrogate the (potential) governance effects of four different PREAs—representing all possible key

Table 1. Selection dimensions, events, considerations, and authority (adapted from Nedeve, Tirado and Thomas (2022))

Selection dimension	Selection event	Selection considerations and authority
Organizational career	Recruitment Promotion Tenure/probation Training	Who decides a researcher's utility for organization, for local field members, for the global field, and determines organizational career progress
Knowledge production	Field information access Field facility access	Who decides integrity and pragmatic concerns about information flows, e.g. open-access policies and which journal subscriptions to hold Who controls access to on- or off-site research facilities
Knowledge dissemination	Field networking Publishing Inclusion in PREA submission	Who sets and enacts criteria about funds for mobility, travel, conference participation, and working time Who decides over publication processes, e.g. prioritizes publication in specific journals, and offers publication bonuses Who decides who is submitted for research assessments, and what outputs convey the research organization's performance, excellence, and reputation

Table 2. Four ideal PREA types from information, judgement and action possibilities

	TYPE 1 Steering I	TYPE 2 Steering II	TYPE 3 Enabling I	TYPE 4 Enabling II
Information	Narrative	Indicators	Narrative	Indicators
Judgement	Research output (research quality judgements made by academics, possibly from different fields, i.e. an authority in theoretical chemistry may be a 'lay academic' in particle physics)	Lay academics Proxies	Research environment (research quality judgements possibly by non-academic groups using proxies to inform judgement, e.g. ranking of journals and/or research organizations)	Lay any group
Action		Material		Reputational

achieve this, and the type of *social action* (rewards and incentives) that follows the judgement.

Depending on whether the PREA informs and determines the *allocation of resources or reputation*, we choose to divide them into 'steering' and 'enabling' types⁵ whereby the former directly influences *funding* decisions, and the latter affects *reputational rankings*. A second analytically sound comparative dimension is the distinction between PREAs using (primarily) *narratives* or *indicators* to inform judgement. This is important because these different information types signal different kinds of game-playing are possible for knowledge communities and research organizations (and their leaders) aiming to maximize resources and reputation (Nedeve and Boden 2006; Gibney 2016; Watermeyer and Derrick 2022). For example, when PREAs use indicators, game-playing can occur around citations, bibliometrics and altmetrics. When PREAs use narratives, game-playing can occur around selecting evaluators, wordplay, and using the quality of journals as a proxy for research quality.

Consequently, the variance along the information, judgement and action dimensions outlines four tentative PREA types (see Table 2).

A fourth comparative dimension distinguishes between national-level and organizational-level operation of PREAs, further accommodating known variations around the world, where research evaluation arrangements may be structured at national level in some contexts, and these may be non-national in others (e.g. see Kolarz et al. 2019).

These dimensions informed our selection of four PREAs. The four PREA contexts we have selected to study we believe

represent significant and sufficient variety to account for the known variance of global PREAs. This, we argue, enables us to do a comparative analysis using four analytically selected PREAs, rather than a much larger set of PREA cases. In other words, we selected PREAs with varying relationships to material resource and reputation allocation, judgement, information collection format and level of operation, that acceptably encompasses and represents the spectrum of possibilities of PREAs worldwide.

3.3 Characterization of the four selected PREAs

In this section, we characterize the four PREAs (Table 2) providing the governance context for our study along their core dimensions. These PREAs are selected to represent, in broad terms, the possible steering/enabling dimensions and the national/organizational levels.

3.3.1 Denmark (primarily national level 'Steering II')

The PREA in Denmark was created following a 2009 political agreement to create a new bibliometric research indicator-based model to distribute basic funding to universities. This was phased-in from 2010 to 2012 and called the Danish Bibliometric Research Indicator or *Bibliometriske Forskningsindikator* [BFI] (Pedersen 2010). By 2012 it allocated 25% of a small portion of block funding based on numbers of outputs registered and reported by universities to be in Level 1 (normal) and Level 2 (high quality) journals and publishers. The remainder was determined by education performance (45%), external funding capture (20%) and PhD completions (10%). The levels were agreed upon by 67

subject area-based expert groups of academics, a professional committee, a technical working group and committee, and a BFI steering committee, informing funding allocations by the Danish higher education and science ministry. The expert groups considered revisions to journal and publisher levels once or twice a year. An optional Level 3 (excellent) was used by some departments for local performance-based pay rewards. This set a national system where a committee structure determined quality proxies for the research outputs of all eight universities in Denmark. As of 2019, the three-level lists included 20,433 journals and 1,163 publishers (Deutz et al. 2021). Each university reports to the ministry annually. The amount of block funding they receive is directly linked to perceived quality via the proxy of academic committees deciding the journal/publisher level rankings.⁶

Financial redistributions across the Danish universities due to the use of the BFI have been low. Universities have gained or lost no more than 0.2% of their BFI-related funding over time. Output growth has varied across fields, but reportedly has mainly occurred in lower-ranked journal/publisher levels, there has been little change to time spent of research, and there has been a reduction in publications in Danish language (Mouritzen and Opstrup 2020).

3.3.2 Netherlands (primarily national level 'Enabling I')

The Netherlands' national PREA—the Standard Evaluation Protocol (SEP)—began in 2003, created by the Dutch Universities (VSNU), the Royal Dutch Academy of Sciences (KNAW) and the Netherlands Organisation for Scientific Research (NWO). It replaced the first Netherlands national evaluation protocol for quality assessment of academic research, created in 1993 (Van Drooge et al. 2013). SEP operates under a 'quasi-formative' assessment rationale. Universities and institutes are required to use the SEP to self-evaluate, through an assessment committee, based on their research units' self-defined goals and strategies. This makes it a bottom-up, institutional self-evaluation using a nationally defined protocol, rather than a top-down process (Kolarz et al. 2019). Research groups (research units) self-report performance evaluation using three SEP criteria: (1) research quality, (2) societal relevance and (3) viability of the research group (Arnold 2017).⁷ In addition, research units address aspects relating to group internal organization—leadership and personnel—and research. The research units determine which indicators they consider relevant to self-evaluate so largely design and own the process themselves (Kolarz et al. 2019).

An external evaluation committee of academic and non-academic experts judges the self-assessment reports and visits research groups. It considers the information in self-assessment reports, bibliometric information (publications, citations, journal rankings), PhD completions, grant income, and the narrative about strategy and plans. Its opinions committee are then captured in a qualitative report to channel recommendations to the research group on changes or actions necessary to improve.

Despite being based on a nationally-agreed protocol, these evaluation reports are *not* connected to national funding distribution. Nevertheless, they are not inconsequential. In the Dutch system, *competition is driven by reputational factors, and changes in publishing practices and symbolic stratification between excellent and non-excellent departments* (Lewis 2015). The pressure for departments to perform better in the

next SEP assessment are largely transferred to researchers, who may adopt a more strategic approach to their publications, grant capture, and career progression (Leisyte and Westerheijden 2014).⁸

3.3.3 Sweden (primarily university-level 'Enabling II')

Sweden's PREA is at university level, with no formal national-level research evaluation, despite a national, indicators-based, performance-based research funding system (Hicks 2012). Without a national structure to evaluate research performance and internationally benchmark the universities, bespoke, organization-level self-evaluation arrangements are conducted by Swedish universities, involving an 'enabling' PREA that draws upon narratives and some indicators. The national performance-based research funding system, proposed in 2008 and implemented in 2009, changed earlier institutional and programme-based audits of research quality. By 2014 it determined 20% of state basic funds allocations to Swedish universities, based on two equally weighted indicators: publications and citations and external funding capture (Hammarfelt et al. 2016). Yet, this indicator-based system resulted in few changes in allocation distributions across Swedish universities (Haake and Silander 2021). In 2013, the Swedish Research Council tried to develop a UK-like, peer-review panel-based national evaluation agreement (SRC 2015). This faced opposition from the Swedish universities so was not implemented (Hammarfelt et al. 2016; Haake and Silander 2021; Lundh 2022).

Swedish universities then developed their own organizational-level PREAs, primarily narrative-based research performance self-evaluations (the first university-wide one was done by Uppsala University in 2007).⁹ University authorities lead the self-evaluations, done every four to six years, and assess preconditions for quality research and areas to improve. Like the Dutch SEP system, this Swedish research performance evaluation is multidimensional, iterative, and future-oriented.¹⁰ Unlike the Netherlands, universities do not follow nationally agreed guidelines to create protocols.

Researchers play an active role in self-evaluations. They contribute to information reports and respond to internal authorities, to an external review committee, and to their peer review panels. The self-evaluations consider how high-quality research is sustained in the long-term, and benchmark if it is internationally competitive. Self-evaluation formats can vary, due to having no national framework. Typically, they consist of self-assessment narratives on: (1) leadership, (2) collegial culture and (3) the quality ecosystem. They inform panel judgements on research performance and research environment.

The self-assessment reports and complementary information are reviewed by committee panels, including internal (academics) and external advisors (academics, other experts), who may make site visits. These panels communicate their assessments in collective reports to university leadership and research units. *These are typically not taken to suggest internal ranking of unit quality or to drive internal funding redistribution.* However, university authorities can consider the self-evaluation report recommendations in annual funding allocation decisions affecting faculties, departments, and individuals. This occurs within large, research-intensive, and small, less research-active Swedish universities (Hammarfelt et al. 2016; Haake and Silander 2021).

3.3.4 The UK (national level ‘Steering I’)

The UK PREA, the REF, began in 1986 as the Research Assessment Exercise (RAE) with intentions: (1) to maximize the economic and social impact of UK university research; (2) to provide evidence of the value of the public investment; and (3) to drive production of excellent research in UK universities to deliver benefits inside and outside academia (Kolarz et al. 2019; Thomas et al. 2020). REF evaluations are a formal, national system consisting of expert review panels organized around subject-based ‘units of assessment’. Panel members are academics appointed for being international subject experts. Users are involved to represent non-academic interests. Reviewers assess quality in each unit of assessment via research outputs (65%), impact (20%) and environment (15%). Panels are intended to peer review submitted outputs (journal articles, books, book chapters, designs, exhibitions) and template-based ‘impact case’ and environment narratives. Some panels also use citation-based indicators,¹¹ and informally use journal rankings as proxies for the output quality (given the large number of publications panels need to review).

The excellence and international competitiveness of units are rated using scales intended to benchmark them by rating work as: *nationally recognized* (1-star); *recognized internationally* (2-star); *internationally excellent* (3-star); and *world-leading* (4-star). For the REF 2021, 157 UK universities submitted, via 1,878-unit submissions, totalling 185,594 pieces of research and 6,781 impact cases involving 76,132 academic staff. These were reviewed by 34 expert panels and four oversight panels engaging 900 academics and 220 research users.¹² The actions following REF evaluations are *material and reputational*. The UK PREA is a ‘strong’ system where results are directly linked to financial allocations (Hicks 2012; Whitley, Gläser and Laudel 2018). REF’s implications for universities are straightforward: the better they perform, the higher their reputation appears, and the more selectively allocated institutional funds they receive from the state higher education funding bodies (with over 50% of basic funding determined by REF results; see Arnold 2017; Kolarz et al. 2019).

3.3.5 Expectations given the variance of these four PREAs

These four PREAs broadly capture Steering I and II and Enabling I and II from our earlier ideal types (see Table 2). As we have noted, they capture a sufficient variety of PREA characteristics to represent known forms of varied research evaluation arrangements globally (see Hicks 2012; Kolarz et al. 2019; Zacharewicz et al. 2019). Covering these four contexts, representing all ideal types, enables us to assert that if quality-related selection effects occur for this field across these four contexts, the same pattern would hold true *even if we selected to study other contexts* for the same field, given they likely mirror the same range of ideal PREA types we are already covering.

Our approach is also to *formulate expectations* regarding the possibility of these four PREA types affecting the choices and behaviours of the local scientists (first-level effects)—in terms of their research quality selections, with implications for whether global field effects *may be possible* (second-level effects) and thus *expectations* of effects. By this, we mean that PREAs, for instance, could affect researchers’ quality-related decisions when the actions following evaluations are *material*,

and research organizations control resources affected by such actions. In these terms, we can expect that the ‘national-level Steering I’ UK REF is the most likely PREA to affect the choices of the members of local knowledge communities, followed by the ‘national-level Steering II’ Danish PREA. Both have PREAs with nationally agreed quality levels used to evaluate performance and allocate funding, with ~50% and 25% of state block funding at stake. We expect that the ‘university-level Enabling II’ Swedish and the ‘national-level Enabling I’ Dutch PREAs are decreasingly likely to affect researcher decisions.

3.4 Research governance and scientific fields: Effect mechanisms

We consider *effect mechanisms* in order to formulate expectations regarding the possibility of first- and second-level research field effects occurring. Effect mechanisms, or process-based accounts, link features of research governance and the properties of scientific fields and allow us to investigate (the possibility of) generating specific effects (Tilly 2001; Demetriou 2009). These mechanisms are theoretically-informed (Gläser 2010; Nedeva 2010; Whitley 2011) and build upon recognizing the relationship between different ‘players’ involved in producing scientific knowledge (including policy and funding bodies). Hence, we can *expect* empirically detectable epistemic effects of research governance on the total research field, or second-level effects, if:

- The field’s *research resources* (see Table 1) are controlled by actors in the research space (e.g. research organizations); and
- *Quality standards* (such as evaluation criteria, notions of research quality etc.) are influenced by research space standards.

These expected epistemic changes are *predictable* only if:

- Research governance influence is aligned across local research spaces (national and regional); and
- The research field is centralized, whereby the core research groups have the authority to influence the epistemic choices of other groups (e.g. topic selection, method, selection, publication strategy, etc.).

By contrast, if the research field itself controls the field’s research resources, *no epistemic change affected by governance regimes could be expected*. If we could expect governance to affect epistemic change, but the influences are *misaligned* across nation-states and regions (different PREAs), the change at the level of the global research field is unpredictable. Figure 2 illustrates the logic of these effects mechanisms.

4. Method

To test our expectations about these mechanisms, we build upon 29 one-hour long semi-structured interviews conducted with members of the local communities of the specific field of CERN-based particle physics, in the four selected research governance contexts (13 UK, 7 Sweden, 4 Denmark, 5

interviews were coded independently by two of the authors then codes for each selection point discussed collectively by all authors. Our focus was, through the interviewees' reported selections, and by building an overall picture of the common pattern of multiple interviewees' responses (from which we excerpt indicative statements, see next section), to analyse who has authority over research resources, local field members or research organization senior leaders, and whether S-type notions (research space quality standards, including those relating to the PREA research governance) affect selections in ways that might change epistemic norms, or whether selections were based upon F-type quality notions, under the authority of the field. The analysis, therefore, focuses on the local field members and their selections at the organizational level then builds from this to generate an aggregate picture.

5. Empirical findings

Given that the specific research field we investigate has strong authority over research quality standards—and its research resources such as access to funding, access to equipment and facilities etc. essentially bypass the national research level—from our framework we *expect* to find that governance arrangements have *little effect* on the workings of *this particular* global research field. Investigating the effect mechanism through the interviews conducted in the four varied PREAs/PREA types allows us to test whether this may vary across national contexts.

Below, we present our results organized in terms of the organizational selection dimensions, e.g. selections in the context of organizational careers, knowledge production and knowledge dissemination.

5.1 Effects of the four PREAs on organizational career-related selection events

Across the four analysed contexts, we found that the overall pattern was that *intellectual aspirations and norms of the field drove organizational career-related selection events*. University-level, organizational career-related incentives and rewards were reportedly not favoured above cognitive and knowledge community career advancement by the four groups of local field members. Local members select new hires for their potential to strengthen the field rather than based on organizational performance-related pressures. They also reportedly value their career advancement and their established colleagues' contributions to the global field and the field's knowledge rather than in terms of organizational career ranks or organization-related rewards.

We asked the interviewed local field members about what constitutes success for them and encouraged them to provide examples. From this, we coded what *selection events* they had touched upon, including recruitment, tenure, promotion, and training (Table 1), and whether their selections indicated enacting F- or S-type quality notions. Across the four contexts, we heard a repeated pattern of F-type, epistemic and field-driven selections by local members, with no reports across all the contexts of recruitment, tenure, promoting, and training being steered by quality-related concerns conveyed from the organization, to signal PREA-related research governance pressures.

Contributing to the field, rather than building organizational career advancement, underpinned how the interviewees

overwhelmingly understood 'success' in all four contexts. The interviewees chose to contribute primarily to the intellectual pursuits of their field in terms of what they published, their analyses, the data they generated, the equipment they made or improved, and the methods they developed. Training and mentoring new generations of researchers was valued in the broader field as a positive legacy of the local field members beyond organizational considerations. Interviewees highlighted overall they would invest their time to further their position in their field community—such as becoming a CERN fellow, being appointed within CERN as a group convenor or leading an experiment—above and beyond getting promoted within their university. The following indicative interview quotes capture this pattern of reported career-related selections repeated by the interviewees:

[Success to me is] the advance of knowledge, to which we make significant steps in our understanding of the physical world. (Interview 1, Sweden)

To me, I think [success] is about really seeing that the things you do make an impact for progress in the field. [...] discovery and making an important contribution to [...] analyses. (Interview 10, Netherlands)

I have not applied [for promotion] mostly because I just don't have time for these things. [...] It gives me a better job title and it gives me some, a few thousand pounds a year more, which is not a big difference. (Interview 20, UK)

[The] key thing was becoming a CERN fellow. That is near royalty [...] That's it. (Interview 9, Denmark)

[C]onvenorships are given [within the field] [...] So you must have a good reputation to get these roles and people just know it. (Interview 7, Netherlands)

A minority of researchers did mention the importance of getting 'a permanent position' (Interview 16, NL) and gaining sufficient 'good funding' and 'citations' for their publications (Interview 14, DK). However, these perspectives were far outweighed by more established researchers involved in training and mentoring in the field. They emphasized that building a track record of contributions to the field was more important than citations *per se*:

[Y]ou have to be very careful about these track records. [...] [We] know from our networks what [...] people have been doing [...] and we can look at what kind of contributions these people have made, and what kind of ideas they have contributed. (Interview 13, Sweden)

The hardest thing in the field in general is identifying the independent researchers who are [later] going to be lead academics. That's what you're looking for at the beginning [...] [Y]ou get a feel for what they've been working on individually and how they went about it. [...] [I]f they're good they'll typically have been put in charge of some measurement. And so these kinds of things are the ways that you distinguish people. And [...] more senior people that

work closely with them can give you a feeling for these things as well. (Interview 23, UK)

Across the four PREA contexts, it became clear that interviewees' selections were predominantly shaped by F-type quality notions of success rather than driven by organizationally set pressures. Organizational career advancement and field community contributions were distinct and not conflated. Success was seen as driven by field recognition rather than organizational career titles.

5.2 Effects of the four PREAs on knowledge production-related selection events

Local field members in all four contexts reported high authority over selections involving access to field-relevant information and field research facilities. Field authority reportedly largely bypassed the influence of local research organizations. Knowledge production selections were driven by field norms primarily favouring open-access publishing (to legitimize public funding investments in CERN regarding access to information). As a repeated pattern from the interviews, the field determined that all its work should be publicly available to all local members across the field. One interviewee stated, *'it is not right that we then should give the ownership of those research results over to journals'* (Interview 1, Sweden).

Access to CERN-related research facilities involved selections driven by field-based, F-type quality notions. This was related to funding for CERN being under the authority of the field. This bypasses the local university organizations so that even local groups in countries that provided less funding into the shared CERN pool could be given access to facilities on an equal basis—if the *field members* decided this was beneficial:

CERN provides all the cost of the facility but the experiments are really supported by the collaborators. So we must all to put money for common funds. But sometimes, for example, a nation can do in-kind contribution [...] Sometimes to do some project we can hire some technician [from a country with fewer resources] because it's easier. It's cost effective. So, there are a lot of way of doing things that could favour a country that had less cash. (Interview 29, UK)

Decisions about access to field research facilities were reportedly open so researchers could determine their intellectual directions. However, this involved reciprocity. It came in return for 'service' tasks to the global field. This once again demonstrated a pattern across the interviews that authority resided within the field. Local research organization leaders did not make choices about access. Funding issues were less important than making 'useful' contributions to the CERN collaboration:

I think people do have the opportunities [to pursue the research they want] [...] [N]ormally the position, part of it is service tasks, [...] [first doing] something for the benefit of the experiment [...] and then normally the physics analysis [of your own] is more flexible. (Interview 21, UK)

[In the experiment] nobody knows about funding there. So there you are successful if you're active in the experiment,

if your [local] group comes with distinctive research projects, research results [...] or anything which is useful for collaboration. (Interview 2, Sweden)

There were a few reported situations where 'external funding' was necessary to support aspects of developing CERN-related equipment (Interview 3, Sweden). However, access to core data and the broader infrastructure was still guaranteed and not determined by local funding conditions. A reported pattern of field-related authority over information and facilities access selections was reinforced by CERN being based at a separate, independent geographic location to all four local research governance contexts. This reportedly afforded flexibility and freedom to local field members. Some interviewees preferred to be situated at CERN, particularly early career researchers. At CERN, they could interact with peers, and more senior researchers interviewed recommended this to them as valuable for their field advancement:

[Our group] has offices at CERN and then students and post-docs have the possibility to be based at CERN for a while. So post-docs usually have the freedom to choose where they want to be based. Most of them choose to be at CERN [...] [O]ne of the things where [we] really support post-docs in their career advancement [is] allowing them to choose where they are based. (Interview 16, Netherlands)

5.3 Effects of the four PREAs on knowledge dissemination-related selection events

Selections regarding access to field networks, including conferences, publishing, and inclusion in PREA-related assessments, also showed a pattern from across all the interviews of more authority with local field members than with the local research organizations. Senior local members noted that they deliberately have an open, cross-topic approach to access to field networks as part of the epistemic traditions of the field, such as in this indicative quote:

[W]e participate in like four or five different topics. [...] [W]e try to have [our local] people at least have experience in all these fields because it prepares them better for later, it makes them a better scientist. And for some, it comes naturally and for some it doesn't [...] But our task is to prepare them. (Interview 5, Netherlands)

Funding to support such experiences and travel was primarily administered by CERN.

Across all four contexts, selections about where to publish were reported by most interviewees as similarly driven by the field's rigorous internal peer review processes and collective decisions about where to publish. The quality of research, as assured by centralized, internal peer review and decisions by working groups and field leaders, reportedly had more weight than any local considerations of journal rankings. As one researcher put it: *'[I]t doesn't really matter where the article actually goes because all we produce is good research'* (Interview 18, UK). This was reportedly due to the internal peer review before any article is sent to a journal. Another indicative example is a researcher who stated that their 'publication strategy' is to 'go after the next big things in physics', to get 'another major discovery, another major result' and 'to

Table 4. Overview of the pattern of selection events recounted by interviewees across the four PREA contexts and local groups

Selection dimension	Selection event	UK (national-level Steering I)	Netherlands (national-level Enabling I)	Denmark (national-level Steering II)	Sweden (university-level Enabling II)
Organizational career	Recruitment Promotions Tenure/probation Training	Field has authority over recruitment, promotions, tenure/probation and training			
Knowledge production	Access to field specific information	Research training done at level of the global field Access to field specific information regulated by the field through open access and maintaining field-specific journals			
	Access to field facilities	Field elite has authority over access to equipment and facilities; funding for fellowships to visit CERN also bypasses the university			+ Some project funding for CERN visits flows through the university, but university administration has no authority over access decisions
Knowledge dissemination	... field networks	Authority over conference presentations, and who delivers them, strictly with the field, and can affect later recruitment decisions			
	... publication outlets	Publication decisions entirely under the authority of the research field; field publications committee decides where outputs are published, using own ranking of quality journal that may not match university management interests. Field also has authority over topic and method selections			
	... inclusion in PREA-related assessment	Researchers select outputs to best reflect their work and contribution. University selects, based on quality proxies, from this pool what is submitted to PREA	Researchers report outputs to their research unit; unit determines indicators relevant to evaluate them	Researchers report outputs that are counted to determine block funding	Researchers report during self-evaluations

optimise things in order to have the maximum impact’ scientifically, rather than to be overly concerned where the research is published (Interview 29, UK).

As a pattern, decisions about where to publish were largely under the authority of the local members, driven by their field practices. Some interviewees were reportedly aware that their universities valued certain outlets more than others:

There are some suggestions, indeed, but I wouldn't call it a pressure. We know that it is considered as great if you publish in Science and Nature. And yeah, people in the university are getting genuinely surprised when they say, 'Oh, you discovered [a particle] but you didn't publish it in Nature?' [...] Because Nature is not one of those journals where we normally publish. (Interview 2, Sweden)

There were instances where some interviewees had *'recently started to send some things now to Nature, and Science'*, mindful that their university considered these journals to be *'prestigious'* (Interview 8, Denmark; also Interview 10, Netherlands). In terms of the overall reported pattern from across all interviews, however, these instances were largely outliers compared to most reported publishing decisions.

Finally, interviewees reported how they and their organizations select their research to be included in PREA-related assessments in their four contexts. Researchers selected to submit works that reflected their contributions to the global field rather than being influenced by organizational expectations about what they should submit. The primary reported selection approach pattern is well captured in the following quote. This stresses how local group members comply with their local PREA-related, nominal submission conditions. Yet these largely do not influence their decisions regarding what work they submit or do. They *'know'* they are *'good'* based on their field's judgements. They *do not need* PREA-related signals to confirm this:

I mean, of course we are involved and we're supposed to produce some documents and whatnot. But it's not that it makes us change anything in our work or anything. We know we're good, right? (Interview 2, Sweden)

Another interviewee indicated their awareness of and compliance with PREA-related nominal reporting requirements. Yet they stated this was only a background concern rather than something that drove their quality selections:

We write a yearly report, you know, how much did we publish [...] The degree of detail to which this is kept, I'm not aware. That's a management thing. But we do have that. (Interview 9, Denmark)

Finally, a UK interviewee noted making specific selections to submit to their PREA (the REF). However, this did not negate the overall reported pattern we heard across the interviews, as this personal strategy was primarily necessitated by this researcher's individual contribution being obscured by their field's convention of listing authors alphabetically on papers. We did not take it as evidence of a selection driven by their local organization's concerns:

In my field, you've got these publications with thousands of authors on them and so, how do you distinguish

yourself? [...] [O]ne of the ways that I do that, is if I've managed to get my name on a paper that has fewer than 30 names on it. I will make sure that that paper ends up in what I choose for the REF. Because that's different from most of my colleagues who will only have papers that have thousands of names on them. (Interview 17, UK)

6. Discussion and conclusion

In this paper, we set out to advance the understanding and empirics of the effects of research governance on the epistemic and structural dynamics of scientific fields. We did that by applying a recent framework for studying governance effects and extending it empirically to include a comparative analysis of CERN-based particle physics field members working in four different governance contexts, using a highly selective approach instead of surveying over 100 countries where this global field operates.

Our study and analysis are founded on this framework and a tentative typology of PREAs, ensuring that our selection includes evaluation and governance arrangements sufficiently different to yield analytically valuable findings and to account for the variety of PREA types globally. Mindful that our objective was not to measure effects but rather to unpack the sequences through which these effects transpire, we set out a theoretically-informed effect mechanism that allowed us to frame expectations. Furthermore, we employed three dimensions along which vital research quality notions-related selections in terms of resources for research occur at the organizational level to structure the empirical work and analysis.

Theoretically, we stated ahead of the empirical findings that we could expect governance effects on the epistemic and structural dynamics of the research field if two conditions were in place: (1) if organizations and institutions from the research space were found to have authority over choices regarding research resources, and (2) if actors from the research field have the power to assert their specific research quality notions during core decisions (e.g. topic selection, publication strategy).

Accounting for the characteristics of the global field studied here, we expected to find that the members of the local knowledge networks *can bypass* local governance influences, and instead the specific demands of the global community determine their epistemic choices. This is mainly because funding for this particular field bypasses local arrangements, including evaluation arrangements (PREAs) and research field-level groups decide what to fund, what to research, access to equipment and publication strategies.

Our empirical investigation confirmed our theoretical expectation based on this mechanism, i.e. that the epistemic choices of the members of the local knowledge networks in this research field were not influenced by the governance context in all four PREA environments, and therefore in the aggregate the total field was not affected. Table 4 offers a comparative overview of the distribution of authority during different organization-level selections. In all contexts, the selection is predicated on the authority and demands of the research field.

Going back to the central question of the paper, namely, do governance arrangements affect the dynamics—epistemic and structural—of global research fields, the answer for this field would therefore be *'no'*. We should stress, however, that this

13. Involving 12 female and 17 male interviewees. These numbers may appear modest but these local research groups are not large, meaning that in our sample we succeeded in gaining interview responses from the majority—in some cases up to 80%—of local field members in each PREA context.
14. Questions addressed selections indirectly by exploring: What does success look like for you? How are people recruited into your group? Have you applied for promotion recently? For discretionary pay? How do you decide where to publish your research? What might make you move to a different university/institute?

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