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Managing individual research productivity in academic organizations: A review of the evidence and a path forward

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ABSTRACT

The management of research productivity is central to university governance and drives a broad range of decisions, including those on hiring, promotion and funding allocation. Policymakers and academic leaders responsible for improving their institutions' research performance need an evidence-based understanding of the organizational factors that can be managed in pursuit of better publication outcomes. Our paper reviews the empirical evidence on the drivers of research productivity that can be actively managed by organizations and policymakers. Such drivers include organizational structures, research culture, features of task environment for academic work, and resource allocation. To advance the state of science in research productivity literature, we then analyze assumptions and highlight mechanisms that need to be explored in order to improve theoretical and methodological state of the field. We suggest directions for future research with the aim to create a deeper and more cohesive body of knowledge on how organizations, funding bodies, and government agencies can influence scientific performance at the individual level. To advance the practice of research management, we offer a rigorous synthesis of existing empirical evidence that can help academic leaders in supporting and developing faculty research productivity within their institutions.

1. Introduction

The emergence of global university rankings and the resulting academic "arms race" (Enders, 2014) in search of international visibility has transformed research from a university faculty's professional vocation into an essential strategic human-capital resource. This "arms race" is part of a broader higher education policy change, which have seen Excellence Initiatives being implemented (under different names, but with the same purpose) in many countries across the world (Civera et al., 2020; Froumin and Lisyutkin, 2015). Research-related metrics account for the majority of variance in the ranking positions that those initiatives seek to improve. Increasingly, the allocation of public funding is linked to research performance indicators (e.g., Civera et al., 2020), with the Research Excellence Framework in the UK being one of the most prominent examples. Consequently, the management of research productivity is now central to university governance and drives academic hiring, HR policies, and funding-allocation decisions. With many different stakeholders (such as faculty staff, doctoral students, external funders, and policymakers) influencing the process of research production, academic leaders face difficult trade-offs in managing research productivity, which is defined as the quantity and quality of scientific publications.

Prior studies report that organizational antecedents explain a significant amount of variance in individual research performance (Ryazanova and McNamara, 2016). While multiple inductive attempts were undertaken to identify organizational factors that influence individual creativity and productivity in science (e.g., Bland et al., 2002; Heinze et al., 2009), the field is still lacking a systematic synthesis of empirical studies which tested the effect of those factors on individual research productivity. Rousseau (2006) called for a move toward evidence-based management as a way to close the gap between management research and managerial practice. This call applied to all sectors, including higher education. Academic managers need access to reliable scientific evidence to make data-informed decisions. Several existing reviews provide useful evidence that could inform hiring decisions, addressing, for example, the link between academic origin and scientific productivity (Sinclair et al., 2014) and that between research self-efficacy and research productivity (Jang and Shin, 2011). Research management, however, is not limited by hiring choices. Yet, we are not aware of similar available evidence to inform decisions about other managerial

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leverages, including resource allocation and organizational structures, among others.[1] Our review seeks to address this gap by focusing on a broad range of factors that can be actively managed by organizations and policymakers to support individual research productivity.

Our structured literature review synthesizes robust empirical evidence from 46 papers published within the fields of Business, Management, Economics, and Sociology. The empirical evidence in those papers has met the criteria for moderate-to-high strength of causality claims (Antonakis et al., 2010), ensuring that the relationships tested go beyond correlations and can be meaningfully interpreted by science and practice.

Our contributions target two main audiences. First, for scholars studying research productivity, our review makes a conceptual contribution by clarifying key constructs, analyzing established assumptions and highlighting mechanisms that have been underexplored in the literature (Post et al., 2020). We then offer conceptual and methodological solutions that could help improve the state of scholarship, and outline a related agenda for future research.

Second, we seek to support those responsible for managing research environments. For current academic leaders (vice-chancellors for research, deans, department heads), we start by organizing empirical research to provide an evidence-based understanding of the organizational factors that are proven to influence individual research outcomes. We then provide specific recommendations on how resource allocation, structural choices, organizational culture and the design of task environment for academic work can be used to support research performance of academics.

We seek to address the needs of two audiences: (1) scholars who study research outcomes as a type of knowledge creation activity and (2) practitioners who manage research in academic institutions. In some institutions, these audiences overlap significantly, in others they are quite distinct and are united only by the common interest in research outcomes as a subject of study or governance. Our dual-purpose approach has its own challenges. Scholarly and practitioner audiences have different mindsets and objectives: while scholars are attuned to the nuances of theoretical arguments and rigor of empirical investigation in theory testing, practitioners are oriented towards actionability of proposed solutions in a specific organizational context (Kieser et al., 2015). Where scholars and practitioners are the same group of academics, those scholar-practitioners have to wear different ‘hats’ depending on the role they are playing in each moment, and change their perspectives accordingly (Carton and Ungureanu, 2018).

We aim to connect research and practice through the lens of evidence-based management. After introducing the method used to select the papers for our review, we start by summarizing the findings, grouping them into categories which correspond to key managerial leverages: *resource* allocation, *structural* choices, the management of organizational *culture/climate*, and the management of *task environment* for academic research. We then explore the conceptual aspect of reviewed papers. The main purpose of our conceptual discussion is to help scholars deliver better empirical evidence in future studies in order to support practitioners in quality enhancement decisions around research performance management. We, therefore, highlight the areas where conceptual improvement is needed and propose solutions which can strengthen the field theoretically and methodologically. Meanwhile, our implications for practice section builds on existing empirical evidence to offer actionable insights for today’s decision making on research management. The implications section is again structured around key managerial leverages, to match the practitioners’ mindset and objectives.

2. Review methodology

The extensive body of research on the factors related to scholars’ ability to produce scientific output in the form of publications is widely distributed across management, sociology, and discipline-specific journals. In order to capture the insights from different disciplinary streams of literature, we followed the approach summarized in Fig. 1 and detailed in the text below.

We searched the Clarivate Web of Science database using the following keywords: *Research productivity, Research performance, Research output*, Scienti* productivity, Scienti* performance, Scienti* output*, Publishing productivity, Publishing performance, Publishing output, Faculty productivity, Faculty performance, Faculty output*, Scholar* productivity, Scholar* performance, Scholar* output**. The keywords sought to capture different wordings of the phenomenon of publishing academic papers. They were generated and agreed upon by the authors based on our knowledge of relevant literature. The results of this keyword search (7995 items) were narrowed down using the following six inclusion criteria.

First, only research published after 1960 was included in the review. To the best of our knowledge, the seminal studies in the sociology of science published in the 1960s (e.g., Merton, 1968) were the first steps toward studying research productivity in academia. Second, only empirical papers and empirical literature reviews were included to focus our review on summarizing empirical evidence. Third, the selected papers had to use causal or correlational analysis to explore individual research productivity as an outcome (or mediating) variable. In the case of qualitative studies, the evidence presented in a paper had to address the factors related to research productivity as a phenomenon of interest. Fourth, research productivity had to be measured at the individual level of analysis. In focusing on individual performance, we sought to offer insights both to academic managers whose job is to select, motivate and develop researchers, and to individual researchers who benefit from understanding which organizational factors can support or suppress their productivity. Fifth, research productivity had to be measured through scientific publications. The papers that used patents as a measure of academic productivity were not included because we wanted to focus on scientific publications as a consistent metric across disciplinary fields. Sixth, we focused on four Web of Science categories: Business, Management, Economics, and Sociology. The focus of our review is on managing a type of employee task performance so Business and Management were intuitive choices of categories for studies on this phenomenon. By examining the references in the selected papers, we identified a body of relevant literature located within the economics of education subfield (hence, the inclusion of the Economics category) and the sociology of science subfield (hence, the inclusion of the Sociology category). Our selection procedure resulted in an initial sample of 271 papers. Once these papers were analyzed, a subsample of 87 papers, which focused on organizational and field-level factors, was selected for this review. Qualitatively, our criteria for inclusion here was a potential ability of managers to influence the factors through deliberate action. The factors had to be among key predictors explored in a selected paper, rather than included as control variables.

In the final step, the sample of 87 papers was analyzed in relation to the strength of their causal claims. Since the main practical purpose of our review is to provide actionable insights to managers in academic institutions, it was particularly important to make sure that the findings from the reviewed literature are meaningful. We followed the approach suggested by Antonakis et al. (2010), which focuses on “methods that allow researchers to test causal claims in situations where randomization is not possible or when causal interpretation could be confounded”. Based on this approach, we classified 8 papers as having “high

[1] A notable exception is a book “How economics shapes science” by Stephan (2012). While being a valuable practice-oriented contribution to the field of research management, the book offers broad insights into organization, group, and individual research productivity rather than a focused investigation of evidence related to individual productivity. In addition, the insights in the book are primarily based on the U.S. data, and the analysis does not include any of the social sciences and humanities.

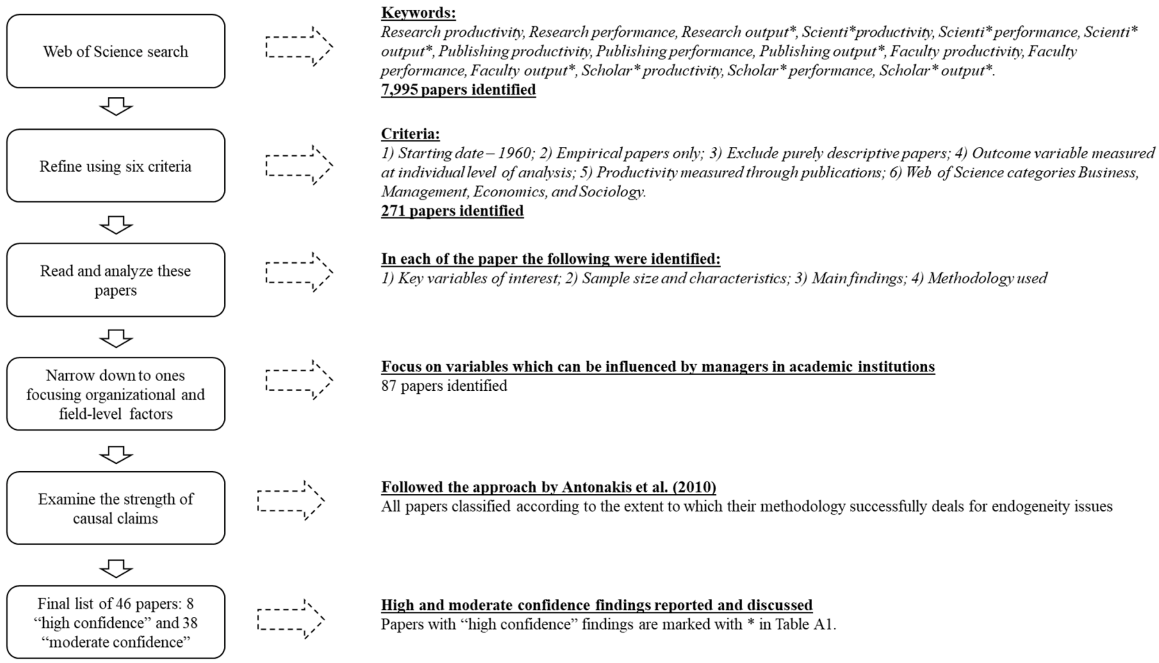

Fig. 1. Literature sampling heuristic.

confidence" in their claims, 38 papers as having "moderate confidence" in their claims, and the rest as having "low confidence" in their claims.

Papers which were classified as "low confidence" have not engaged in the deliberate investigation of the endogeneity issues and failed to include a number of important variables into research design. Papers classified as "moderate confidence" had at least one important variable omitted (most often – gender or a metric of professional network), often failed to control for fixed effects at the level of organization, but actively sought to reduce the influence of potential endogeneity. Papers classified as "high confidence" control for fixed effects at the organizational level, had actively sought to tackle endogeneity and included key variables into their research design, as appropriate (some of the controls might be missing, since it is usually impractical to include all theoretically plausible controls into a model with a finite sample size). The details of this analysis for papers included in our review are provided in the online supplement.

In the findings section, we report the empirical insights from 46 high and moderate confidence papers. Table A1 in the Appendix reports their research design, with the focus on methods used to strengthen causality claims. High confidence papers are marked with an asterisk in Table A1 in the Appendix. Since empirical insights from papers with weak causal claims could not be discussed with any degree of confidence (Antonakis et al., 2010), we do not report them in the paper. As a robustness check, we compared key concepts discussed in these papers with the concepts discussed in 46 papers included in the final sample, following the concept matrix approach proposed by Webster and Watson (2002). This comparison demonstrated that papers excluded due to weaker causality claims have not covered any conceptual topics that have not been already present in the final sample of 46 papers.

3. Organizational and field-level antecedents of individual research productivity

Full findings of 46 reviewed papers are presented in Table A1 in the Appendix. We structured them according to the outcome variable; consequently, papers which explore more than one metric of research performance appear more than once in the table. We focus on two distinct outcome metrics which were most widely used in the papers: the volume of research (column 5 in Table A1 in the Appendix) and the scholarly impact of research, measured by citation count (column 6 in Table A1 in the Appendix). Before summarizing the evidence in Table 1 below and discussing conceptual challenges in the current empirical literature, we introduce key managerial leverages through which institutions influence individual research outcomes.

3.1. Research performance management through the practice lens: key managerial leverages

Resource allocation includes managerial actions regulating access to different types of resource necessary for academic work, such as financial resources, human resources, time for research, and infrastructure. While managers have (almost)[2] full control over human resources, time for research, and infrastructure (with the caveat that department-level managers often have to negotiate access to resources at the level of university leadership), control over financial resources represents a more complex issue. Some factors, such as performance-based pay (Heywood et al., 2011; Pfeffer and Langton, 1993) and wage dispersion in the department (Pfeffer and Langton, 1993) are easier to control, especially in private institutions. In contrast, national and regional funding, as well as the extent to which the country's level of wealth transforms into funding for science, are more difficult to manage at the organizational level. There are, however, ways to facilitate access to those financial resources, for example, by setting up a well-functioning research development offices which help with grant applications, or by active engagement with governmental stakeholders to influence education and R&D spending at the national level.

Structural choices made by managers refer to the broad range of decisions which influence the way researchers are educated (Shibayama, 2019) and developed (Muschallik and Pull, 2016), the composition of research units and departments (e.g., Kim et al., 2011; Slavova et al., 2016), and the way research process is managed (Murayama et al., 2015). These choices have impact on research performance by

[2] We acknowledge that there are different university systems worldwide, and that the level of public regulations varies across countries. This, as well as the differences between public and private institutions in managing resources, has an impact on the level of the control that managers might have.

Table 1
Summary of the findings.

Key managerial leverages	Antecedents	Relation to the volume of research	Relation to the scholarly impact (paper citations)
Resource allocation	*Financial resources at macro-level*		
	Location in a country with lower income than the US	(-)	(-)
	Financial resources at the national/regional level		
	Research funding (overall), average number of grants	(+)	(+) substantive funding
	National/public research funding	(+) research contracts	(+) public funding has an inverted U-shaped relationship
	Research funding of doctoral students	(+)	
	Proportion of funding from industry	(-) Inverted U-shaped relationship	(-)
	Number of commercial contracts	(+)	(+)
	Repeated funding from applied programs	(-) stronger positive impact on moderate quality researchers, stronger negative impact on high quality researchers	(+) small positive effect
	Fragmentation of funding	(-)	
	Financial resources at the institutional/departmental level		
	Performance-based pay	(+)	
	Wage dispersion within department	(-)	
	Human resources		
	Teaching assistants (who reduce teaching load)	(+)	
	Number of graduate students/postdocs in a lab	(+)	
	Time available for research		
	Teaching load (hours of teaching)	(-)	(-) only for top researchers
	Not teaching graduate credit classes	(-)	
	Time spent performing research with students	(+) graduate students contribute to peer-reviewed research, undergraduate students contribute to other types of research	
	Service load	(-)	
	Consulting	(-) increases the probability of exiting academic publishing, especially in the case of private sector consulting	(-) public sector consulting, especially for junior researchers
	Spin-off activity	(-)	
	Scientists applying for grants	(+) even if they do not obtain the grants (-) because time spent applying reduces research time	(-) even if they do not obtain the grants
	Infrastructure		
	Adoption of IT technology by an institution	(+)	
Structural choices	*In doctoral/postdoctoral education*		
	Doctoral program's orientation toward top journals	(-)	(+)
	More autonomous approach to doctoral training	(+) long term (-) short term	
	Exploratory training (new research field)	(-) joint publications with a supervisor	
	Racial diversity within a PhD program	(+) for African American and International graduates, but unrelated to the research performance of graduates from other racial groups	
	Sequential model of postdoctoral training (relative to the concurrent model)	(+)	
	In research teams		
	Separation of the roles of research manager and scientist	(+) especially in larger teams	(-) because integration of roles supports serendipity, which leads to more novel and impactful research
	Size of a research unit	(+) publish more in international than in national peer-reviewed journals (and vice versa)	
	At the department/school level		
	Human capital of colleagues (measured as the quality of their PhD)	(+)	
	Specialization of the department	(+)	
	Research visibility of organizational environment	(+)	(+)
	Research visibility of newly hired faculty members	(+) of existing faculty members with short tenure (-) of existing faculty members with long tenure	(+) of existing faculty members with short tenure (-) of existing faculty members with long tenure
	Higher number of international colleagues	(+) for US-born and US-educated faculty members only	
	Participation in formal mentoring programs	(+)	
Organizational culture and climate	*At the department level*		
	A climate of cooperation at departmental level	(+)	
		(-)	

(continued on next page)

Table 1 (*continued*)

Key managerial leverages	Antecedents	Relation to the volume of research	Relation to the scholarly impact (paper citations)
	Innovating climate in the department		
	Faculty's satisfaction with autonomy, intellectual challenge and responsibility	(+)	
Task environment	*Scientific communication*		
	Academics' use of the Internet for scientific purposes	(+)	
	Long-distance co-authorships		(-)

(+) - positive relationship, (-) - negative relationship.

orchestrating access to knowledge and skills, and influencing role expectations. For example, doctoral programs structured with an emphasis on autonomous training put students into the role of independent scholar and prioritize exploration of novel research avenues rather than quick publication outcomes (Shibayama, 2019). In another example, larger research units focus more on international peer-reviewed outlets and smaller units focus on national outlets (Horta and Lacy, 2011), reflecting different expectations in terms of global versus local visibility and impact.

Organizational culture can be defined as "a shared and learned world of experiences, meanings, values and understandings which inform people" in organizations (Alvesson, 2012). The related concept of organizational climate is defined as "the meanings people attach to interrelated bundles of experiences they have at work" (Schneider et al., 2013). Management of culture and climate seeks to guide researchers towards higher performance by influencing their career scripts (Dany et al., 2011; Duberley et al., 2006). Individuals attend to information cues from organizational environment and interpret them as calls for action. This interpretation shapes their behavior if they seek to achieve success within 'the rules of the game' (i.e., career script) imposed by an organization. Specifically, vibrant research culture sends a signal that everyone is expected to engage in research, and research publications (or other signals of research success, such as awards or grants) become a currency that drives social status of individuals in an organization. At the group level, culture might influence the perception of authority, providing higher legitimacy to those individuals whose behavior is more aligned with organizational values.

Task environment is the final category which we consider. This concept, introduced by Ployhart and Moliterno (2011), refers to the setting and conditions in which employees are engaging with a task at hand. Complexity of the task environment describes the degree of interdependence among employees in the process of delivering task performance. Relevant features of task environment which emerged from our review mostly refer to communication processes that support knowledge production in research teams (e.g., Mamun and Rahman, 2016). However, task environment might also include the temporal structure of research work and the features of physical environment in which research is produced.

3.2. Conceptual challenges in the current empirical literature

3.2.1. Construct clarity – the multiple meanings of "research productivity"

The first fundamental issue that emerged from our review of the literature is the lack of conceptual clarity around our main phenomenon of interest. Given the broad array of metrics used to operationalize it, including some which are in direct conflict with each other, we believe that the term "research productivity" became misleading[3] and should no longer be used as an umbrella term for research outcomes in academia. Instead, each study should specify upfront which metrics were used as outcomes and why. While problems with using archival proxies are common in strategic management research (Ketchen et al., 2013), of which the management of scientific performance is a subfield, we do not do ourselves a favor by ignoring them. For example, Civera et al. (2020) demonstrated that Excellence Initiatives in Germany and Italy, which intended to support research productivity in general, led to very different performance outcomes depending on the metrics selected for analysis.

Empirical findings demonstrate that it is crucial, for example, to distinguish between the volume of research and the scholarly impact of research. Some factors, such as country-level wealth (Kahn and MacGarvie, 2016), public funding (Alonso-Borrego et al., 2017; Beaudry and Alloui, 2012; Benavente et al., 2012; Fedderke and Goldschmidt, 2015; Defazio et al., 2009; Jacob and Lefgren, 2011a), number of commercial contracts (Clark et al., 2016), and research visibility of new colleagues (Slavova et al., 2016) have similar influence on volume and scholarly impact. Others, however, have an opposite effect on these two metrics. For example, structuring the doctoral program in a way that prioritized publications in top journals leads to higher life-time scholarly impact, but lower volume of research (Ryazanova and McNamara, 2016). Similarly, the choice whether to integrate the roles of a researcher and a manager in a research team becomes a trade-off between volume and scholarly impact (Murayama et al., 2015). The former is facilitated by separation between these two roles, especially in larger teams, where coordination costs are higher. The latter is facilitated by integration of the roles, because it promotes serendipity in scientific search, which eventually leads to more impactful work. In addition, Goldfarb (2008) found that repeated funding from applied government programs had an overall negative effect on volume of research (albeit the outcome is dependent on the quality of a recipient), but overall small positive effect on the scholarly impact. Even if the effect is not opposite, the relative importance of factors can differ for these two outcomes. In a comparative study, Ryazanova and McNamara (2016) found that research visibility of an organizational environment explains only 4% of variance in the life-time volume of research, but 14% of variance in the life-time scholarly impact.

It is important to distinguish between observing mixed results from different studies in relation to the same metric and observing opposite results in the same study for conceptually different metrics. In the first case, more detailed investigation of boundary conditions and, potentially, meta-analysis of findings is in order. For example, in our review, the relationship between public funding and scholarly impact was found to be positive (e.g., Hottenrott and Lawson, 2017; Tahmooresnejad and Beaudry, 2015) or inverted U-shaped (Tahmooresnejad and Beaudry, 2019). Similarly, the relationship between the proportion of funding from industry and the volume of research was found to be negative (Hottenrott and Thorwarth, 2011) or inverted U-shaped (Banal-Estanol et al., 2015). Finally, Ayoubi et al. (2019) found that applying for funding delivered the increased volume of research, but in the study by Prager et al. (2015), the more time researchers spent on grant applications, the lower was their volume of research.

In the second case, different mechanisms are at play and it would not be reasonable to assume that the difference in the sign of relationship is due to some missed contextual factor. For example, studies indicate that papers with higher statistical power and sophisticated testing of construct validity and causality attract more citations (e.g., Antonakis

[3] The original term came from economics and was intended to measure output of research per input of resources, but it has been rarely used in its original meaning, and instead is used to mean the outcome of research process. So, the term "research productivity" is not used by most authors in line with the original definition of the concept, which is problematic in and of itself.

et al., 2014). The reason for it is that such papers offer the readers more confidence in the robustness of their findings. Yet, it takes more time to collect larger datasets which offer higher statistical power and to design the additional tests which would ensure construct validity. Striving for this level of methodological excellence makes writing highly cited papers a lengthy endeavor, which might not be attractive to researchers seeking to maximize the volume of their research.

A large number of papers in our review have focused on one metric only. Since an assumption that all factors should work similarly for the volume of research and its scholarly impact has been falsified by the studies in which this does not happen, we cannot any longer make this assumption. As a result, as seen in Table 1, our knowledge is quite fragmented. We know, for example, that fragmentation of funding has a negative effect on the volume of research (Mali et al., 2017) and that performance-based pay has a positive effect on the volume (Heywood et al., 2011; Pfeffer and Langton, 1993), but we do not know what effect these factors have on scholarly impact. Equally, we know that long-distance co-authorships suppress the scholarly impact (Hamermesh and Oster, 2002), but we are not sure whether they have the same effect on the volume of research.

3.2.2. Analyzing assumptions – the role of individual agency in producing research outcomes

While all studies included in this review focused on the research outcomes at the individual level of analysis, authors seemed to take a very different stance on how 'individual' research performance was. Some papers had an explicit focus on individual scientists in isolation from their organizational environment. For example, Fedderke and Goldschmidt (2015) studied the individual recipients of a research chair funding, Goldfarb (2008) studied researchers funded by NASA grants, Feeney and Welch (2014) focused on Primary Investigators (PIs) and co-PIs. There is a valid logic behind this approach. Scientists enjoy the independence and responsibility that their occupation provides, and satisfaction with independence leads to higher performance, at least in terms of the volume of research (Kim et al., 2011). In addition, with research performance being partly dependent on gatekeepers outside their workplace, such as journals or professional bodies, scientists' identity often has a stronger relationship with their discipline rather than their employer.

Other studies provide evidence for a more socialized view of research production. Disciplinary and organizational contexts play an important role in moderating the influence of public funding on the volume of research (Jacob and Lefgren, 2011b), such as that researchers in biological sciences, especially those based in hospitals, benefited from the funding more than researchers in other disciplines and organizational settings. Researchers are also influenced by the quality of peers (Long and McGinnis, 1981; Neri and Rogers, 2013; Slavova et al., 2016), specialization and organizational climate of their department (Bosquet and Combes, 2017; Smeby and Try, 2005) and racial diversity within their research environment (Kivlighan, 2008). Distribution of rewards within research units plays a role in individual performance, with high wage dispersion negatively influencing the volume of research (Pfeffer and Langton, 1993).

Scientific ideas also seem to be produced in interaction with others. While the use of internet for scientific purposes increases the volume of research (Mamun and Rahman, 2016) and the number of long-distance co-authors (Hamermesh and Oster, 2002), personal face-to-face communication delivers higher scholarly impact than internet-enabled long-distance collaborations (Hamermesh and Oster, 2002). Some of the influences are more nuanced, such as the positive influence of a higher number of international colleagues, which only works for US-born and US-educated faculty members (Kim et al., 2011).

3.2.3. Analyzing assumptions – the changing nature of academic researchers' work

The taken for granted assumption in the literature is that academic work involves three key activities: research, teaching and some kind of administrative work (also called service), which is related either to teaching (for example, the roles of Program Directors) or to research (for example, administrative duties of managing a funded project or a research center). Yet, increasingly, the evidence in the literature points towards another distinct activity that becomes a requirement for career success in academia, namely practice engagement. Some forms of practice engagement, such as patenting, have been integral part of academic work in some disciplines for a long time; however, current trend towards higher accountability in academia means that a broader range of practice engagement is required and that this requirement now applies to social sciences as well. At the conceptual level, this change requires scholars to expand their view of teaching-research-service nexus to include the fourth aspect of practice engagement.

A number of studies in our review clearly point to the trade-offs between delivering research outcomes for academic stakeholders and outcomes for stakeholders outside academia. The theme of science-practice gap is not new in academia (see Kieser et al. 2015 for a recent review); however, it becomes increasingly relevant due to external pressures on academic science to prove its value for society. Our review provides additional evidence on the difficulty of managing this trade-off.

In the reviewed papers, we observed two types of engagement with stakeholders outside academia: the direct engagement with industry or public sector partners, and the engagement through teaching. The effect of both types of engagement on research outcomes is mostly negative. Specifically, proportion of funding from industry has a negative relationship with both the volume of research (Hottenrott and Lawson, 2017; Hottenrott and Thorwarth, 2011) and its impact (Hottenrott and Thorwarth, 2011; Tahmooresnejad and Beaudry, 2019). This effect is, however, dependent on the type of research, with the volume of applied research being supported by industry funding rather than suppressed by it. Consulting and spin-off activities reduce the volume of research (Barbieri et al., 2018; Fudickar et al., 2018) and increase the probability of a scientist exiting academic research, with public sector consulting also having a negative effect on scholarly impact (Fudickar et al., 2018).

Engagement with practice through teaching and service also has a negative relationship with the volume of produced research (Fox and Milbourne, 1999; Taylor et al., 2006). Here, however, the picture is more nuanced. Exploring the different aspects of teaching and the connection between teaching and research activities, Horta et al. (2012) found that academics who did not teach graduate classes had a lower volume of research, and that doing research with undergraduate and graduate students can increase the volume of research. Supporting this finding, Nag et al. (2013) confirmed that the number of graduate students in the lab increased the volume of research, despite the additional burden of supervision that should come with a larger number of students.

3.2.4. Mechanisms of research outcome emergence: selection and/or development of productive researchers

The ultimate objective of research management is to achieve higher research performance; however, different studies focus on different mechanisms behind the emergence of this outcome. Several of the reviewed studies focused on the issues related to the selection of the most productive researchers. The findings of these studies did not paint a clear picture. In the study of NASA-funded scientists, researchers of moderate quality benefitted more from funding than their high quality peers (Goldfarb, 2008). Similar results were found by Kelchtermans and Veugelers (2011) in their study of scientists in KU Leuven and by Graddy-Reed et al. (2018) in the study of research funding given to doctoral students in the US. Yet, in the study of research chairs in South Africa, Fedderke and Goldschmidt (2015) found that the highest increase in the volume of research was among the most productive researchers and were, consequently, recommending more stringent criteria to allocate funding to the most productive scholars.

Other studies focused on the role of organizational and field-level factors in developing researchers. For example, research funding can help narrow the gender gap in the volume of produced research (Aboal and Vairo, 2018). Providing academics with the access to IT technologies had a particularly strong positive effect on female researchers and researchers from non-elite institutions (Ding et al., 2010). The studies by Shibayama (2019) and Ross et al. (2016) also demonstrated that it is the structure of a doctoral program, rather than the selection of students with particular characteristics, that leads to specific scientific outcomes. Finally, in the study explicitly focusing on personnel development, formal mentoring programs had positive effect on the mentees' volume of research (Muschallik and Pull, 2016).

4. Future research agenda

How can scholars address these conceptual issues to improve the theoretical and methodological state of our field? In this section, we are offering some suggestions for future research avenues and highlight related literatures that have a potential to add value to future studies.

4.1. Research performance construct clarity

One of the reasons for the lack of conceptual clarity around research performance is a very fragmented and underdeveloped state of theory used to study research outcomes. Table 2 below shows theoretical and empirical roots of reviewed studies (see also column 4 in Table A1 in the Appendix). These were identified by analyzing keywords provided by the authors and reading the conceptual/literature review section of each paper, with particular attention to the section of each paper that stated this paper's contributions, because this is where authors often state which conceptual conversations they consider themselves to be part of. We also used concept matrix, as recommended by Webster and Watson (2002), to identify core concepts within each paper – this helped us produce more refined version of theoretical frameworks for that cases where authors used very broad categories in the text (e.g., "behavioral science") or have not provided any keywords.

Out of six most frequently used frameworks/literatures, two are purely empirical (focusing on research funding and on science-industry links) and another one (sociology of science) is descriptive; thus it does not qualify as a theory in the same sense as we use this term in business and management research (e.g., Bacharach, 1989). Studies using economics of science approach have their roots in economic theory, but usually do not spend much time exploring and explaining conceptual assumptions and mechanisms of action, so are, in essence, mostly empirical as well. Similarly, many studies building on knowledge networks literature and doctoral education research deal with their theoretical roots in a cursory manner, without leveraging the full benefits of conceptual knowledge. By the standards set in Sutton and Staw (1995), these papers have no well-developed theory either.

The lack of clearly articulated theoretical assumptions makes it more difficult to establish construct validity and leads to the arbitrary choices in the use of metrics. Hence, there is an opportunity to fill in the gaps in knowledge left by current studies and to continue research from a more theory-informed standpoint. For example, an exploration of the question about the influence of departmental resources on the impact of research can build on the studies of organizational status and reputation (e.g., Fombrun and Shanley, 1990). This would enable scholars to unpack the relationship between organizational reputation (which can be boosted through resource-intensive activities) and individual knowledge consumption choices, reflected in citation behavior. The studies of academic institutions are often confined to conversations set in academic context; yet academic organizations are not dramatically different from other types of knowledge-intensive organizations. We need to be explicit about what makes academic context unique and find the balance between making good use of theories tested in other contexts and controlling for meaningful differences in contexts (Whetten, 2009) which would allow us to define the boundaries of theories' applicability.

To understand the mechanisms linking different aspects of scientific performance, future research can draw upon sociology of science and scientometrics literatures (e.g., Geisler, 2005; Simsek et al., 2013; Wang et al., 2012). Due to the proliferation of new metrics used to assess research outcomes, it is crucial to establish construct validity of these metrics and understand what that they are measuring, from the conceptual point of view. In particular, better conceptual understanding is needed for hybrid metrics, such as h-index, which combine volume and impact of research (Sugimoto and Larivière, 2018). It is also important to ask the *why* questions alongside the *how* and *when* questions, and this is where qualitative research can be particularly helpful. For example, the question why some research attracts more citations than other has been asked before (e.g., Antonakis et al., 2014), but the answers to this question have not yet been used to build a theory that links volume and scholarly impact, explaining why some predictors have different effect on volume and impact.

Conducting research from a more theory-informed standpoint will also help authors make theory-informed choices on variables that they need to include in their models, thus improving methodological strength of the studies. While some methodological weaknesses in reviewed studies were due to the lack of available methodological solutions at the time of the studies' publication, many of the weaknesses, especially those related to omitted variables, could have been avoided by adopting a more theory-driven approach to research design. In addition, concept clarity in defining outcome variables creates better opportunities for meta-analyses of empirical findings, which are key to evidence-based management of research in academia. It is worth noting that out of 46 papers in our review, only 12 report correlations between variables used in their studies. It is concerning that the majority of authors do not provide data which is necessary for meta studies. Journal editors need to tackle this issue in order to set appropriate scientific standards for reporting the results of quantitative research.

Table 2
Theoretical frameworks and empirical literatures used, as % of the total number of papers.

Theoretical frameworks/ empirical literatures	Percent of papers
Empirical literature on research funding	39%
Economics of science	30%
Knowledge networks	24%
Sociology of science	17%
Empirical literature on science-industry links	15%
(Post)doctoral education	15%
Human capital	9%
Academic careers	7%
Literature on research-teaching-admin nexus	7%
Literature on the role of gender in academic careers	7%
Role of communication technology in knowledge outcomes	7%
Peer effects	4%
Group composition and dynamics	2%
Academic entrepreneurship	2%
Attention-based theory	2%
Diffusion of innovation	2%
Economic geography	2%
Equity and distributive justice	2%
Learning theory	2%
Reward structures	2%
Social comparison theory	2%
Social role theory	2%
Stereotype threat literature	2%
Task autonomy	2%
Two-factor theory of motivation	2%

Note: more than one framework or literature can be used per paper, with the average of two and the maximum of five frameworks/literatures per paper.

4.2. Assumptions about individual agency versus social embeddedness

The tension in the literature between individual agency and social

Table A1
Organizational and field-level predictors of the volume and scholarly impact of research.

Authors (year)	Sample	Research design/method to ensure causality/data source	Key theoretical framework (s)/literature streams used	Key findings (volume of research)	Key findings (scholarly impact of research)
Aboal and Vairo (2018)	236 science and technology researchers in Paraguay	Longitudinal. PSM and difference-in-difference design. Uses CV data, bibliometric data.	*Economics of science; literature on the role of gender in academic careers*	Monetary subsidy to incentivize research has some positive effect on narrowing the gender gap in the volume of research.	n/a
Alonso-Borrego et al. (2017)	2734 Spanish researchers, multidisciplinary	Lagged design (DV measured repeatedly). Bias-correcting matching. Uses HR data, bibliometric data.	*Human capital; empirical literature on research funding*	Public research contracts have positive effect on the volume of research and the impact factor of journals where research is published.	n/a
Ayoubi et al. (2019)*	775 Swiss science, engineering, and medicine researchers	Lagged design (DV measured repeatedly). PSM, control for past performance. Uses HR data, bibliometric data	*Empirical literature on research funding*	Scientists applying for grants have higher volume of research and publish in journals with higher average Impact Factor even if they do not obtain the grants.	Scientists applying for grants have lower scholarly impact.
Banal-Estanol et al. (2015)*	3991 engineering researchers from 40 UK universities	Longitudinal. GMM with instruments, control for past performance. Uses CV data, bibliometric data.	*Knowledge networks; attention-based theory; empirical literature on science-industry links*	Proportion of funding from industry has an inverted U-shaped relationship with volume of research.	n/a
Barbieri et al. (2018)	825 Italian researchers, multidisciplinary	Lagged design (DV measured repeatedly). PSM, control for past performance. Uses CV data, bibliometric data.	*Academic entrepreneurship; literature on science-industry links*	Spin-off activity is negatively related to the volume of publications.	n/a
Beaudry and Allaoui (2012)	907 Quebec nanotechnology scientists	Longitudinal. 2SRI. Uses bibliometric data	*Knowledge networks; empirical literature on research funding; empirical literature on science-industry links*	Larger public grants exponentially increase the number of published articles.	n/a
Benavente et al. (2012)	3143 Primary Investigators in Chile	Cross-sectional. Regression discontinuity design. Uses HR data, bibliometric data.	*Economics of science; empirical literature on research funding*	National research funding positively influences the volume of research.	n/a
Bosquet and Combes (2017)	All economics academics in France (1990–2008)	Longitudinal. Control for individual heterogeneity. Uses HR data, CV data, bibliometric data.	*Economics of science; knowledge networks; peer effects*	The presence of other academics specialized in the same field and the share of the department's publishing output in this field are positively related to the volume of publications and the quality of outlets.	n/a
Clark et al. (2016)	488 biomedical researchers in 1 research institute in Australia	Longitudinal. Control for individual fixed effects. Uses HR data, bibliometric data.	*Empirical literature on research funding*	Research funding is positively related to the volume of research Number of commercial contracts is positively related to the volume of research (and vice versa).	Number of commercial contracts is positively related to scholarly impact (and vice versa).
Defazio et al. (2009)	294 chemistry researchers funded by EU framework program	Longitudinal. Instrumental variables. Uses CV data, bibliometric data.	*Sociology of science; knowledge networks; empirical literature on research funding*	Research funding is positively related to the volume of research.	n/a
Ding et al. (2010)*	3114 life scientists from 314 US institutions	Longitudinal. Control for past performance. Uses bibliometric data.	*Diffusion of innovation; role of communication technology in knowledge outcomes; economics of science; literature on the role of gender in academic careers*	Adoption of IT technology by an institution has a positive effect on the volume of research. Women and academics in non-elite institutions benefit more from this effect.	n/a
Fedderke and Goldschmidt (2015)	301 South African researchers, multidisciplinary	Lagged design (DV measured repeatedly). PSM. Uses bibliometric data.	*Empirical literature on research funding*	Substantive funding is associated with the increase in the volume of research, but the increase is moderate and has a high cost. The increase is higher for researchers with higher past performance. The effect is discipline-specific: not significant for business, economics, social sciences, and engineering.	Substantive funding is associated with the increase in scholarly impact, but the increase is moderate and has a high cost. The increase is higher for researchers with higher past performance. The effect is discipline-specific: not significant for business, economics, social sciences, and engineering.
Feeney and Welch (2014)	1598 US faculty in science and engineering	Longitudinal. Control for past performance. Uses survey data.	*Sociology of science; social role theory; literature on the role of gender in academic careers;*	Research funding is positively related to the volume of research. The results are stronger for PIs	n/a

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Table A1 (*continued*)

Authors (year)	Sample	Research design/method to ensure causality/data source	Key theoretical framework (s)/literature streams used	Key findings (volume of research)	Key findings (scholarly impact of research)
			empirical literature on research funding	relative to co-PIs. It takes longer for female researchers to transform funding into a performance benefit.	
Fox and Milbourne (1999)	150 academic economists in Australia	Lagged design (DV measured repeatedly). Control for past performance and robustness checks. Uses survey data.	*Economics of science*	Average number of grants is positively related to the volume of research. Teaching load (hours of teaching) is negatively related to the volume of research. Service load is negatively related to the volume of research if a broader metric of research is used.	n/a
Fudickar et al. (2018)*	951 academics in Germany, multidisciplinary	Lagged design (DV measured repeatedly). Control for past performance, 2 step method, LES models, instrumental variables. Uses survey data, bibliometric data.	*Empirical literature on science-industry links*	Consulting (especially in the private sector) increases the probability of exiting academic publishing. This effect is more pronounced for pre-PhD researchers and full professors.	Public-sector consulting is related to lower scholarly impact, especially for junior researchers.
Goldfarb (2008)	221 university researchers funded by NASA aerospace engineering program	Longitudinal. Instrumental variables. Uses CV data, bibliometric data.	*Sociology of science; empirical literature on science-industry links; empirical literature on research funding*	Repeated funding from applied programs negatively influences the volume of research. Funding has more beneficial effect on researchers with moderate performance relative to researchers with high performance.	Repeated funding from applied programs has a small positive effect on scholarly impact.
Graddy-Reed et al. (2018)*	562 life science graduate students in the US	Longitudinal. Difference-in difference design, CEM, control for individual fixed effects. Uses CV data, bibliometric data.	*Empirical literature on research funding; (post)doctoral education*	Research funding of doctoral students is positively related to the volume of research and the rank of journals where they publish. This effect is driven by graduate students without publications prior to applying for funding.	n/a
Hamermesh and Oster (2002)	384 authors of papers in 3 major economics journals	Longitudinal. Control for past performance. Uses CV data, bibliometric data.	*Economics of science; knowledge networks; role of communication technology in knowledge outcomes*	n/a	Long-distance co-authorships are related to lower scholarly impact.
Heywood et al. (2011)	282 faculty members in 1 Chinese university	Longitudinal. Difference-in-difference design and individual fixed effects. Uses HR data, bibliometric data.	*Economics of science*	Performance-based pay is positively related to the volume of research.	n/a
Horta and Lacy (2011)	283 research units in Portugal, multidisciplinary	Cross-sectional. Control for average productivity per career year. Uses HR data, survey data.	*Economics of science; knowledge networks*	Academics at larger research units publish more in international than in national peer-reviewed journals (and vice versa).	n/a
Horta et al. (2012)	Nearly 16,000 faculty members in US higher education institutions, multidisciplinary	Cross-sectional. Control for average productivity per career year. Uses survey data.	*Literature on research-teaching-admin nexus*	Academics who do not teach graduate credit classes have lower volume of research. Teaching assistants (who reduce teaching load) positively affect the production of only one output: the production of articles in refereed journals. Time spent performing research with graduate students mostly impacts the production of articles in refereed journals. Integrating undergraduate students into research activities leads to an increase in the productivity of the faculty in terms of articles in non-refereed journals,	n/a

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Table A1 (*continued*)

Authors (year)	Sample	Research design/method to ensure causality/data source	Key theoretical framework (s)/literature streams used	Key findings (volume of research)	Key findings (scholarly impact of research)
				writing of chapters and reviews, and books and reports.	
Hottenrott and Lawson (2017)	807 engineering academics in 15 UK universities	Longitudinal. PSM, control for past performance. Uses HR data, bibliometric data.	*Empirical literature on research funding; empirical literature on science-industry links*	Amount of funding is positively related to volume of research. For basic research, industry funding decreases the marginal utility of public funding slowing down the increase in publications. For applied research, industry funding complements public funding, jointly leading to higher volume of research.	Amount of public funding is positively related to scholarly impact. Industry funding decreases the marginal utility of public funding.
Hottenrott and Thorwath (2011)	678 science and engineering professors in 46 universities in Germany	Lagged design (DV measured repeatedly). Control for past productivity. Uses survey data, bibliometric data.	*Empirical literature on research funding; empirical literature on science-industry links*	Higher proportion of industry funding is related to decrease in the volume of research.	Higher proportion of industry funding is related to decrease in the scholarly impact.
Jacob and Lefgren (2011a)	12,189 applicants for NIH postdoctoral grants, multidisciplinary	Longitudinal. Regression discontinuity design. 2SLS. Uses HR data, bibliometric data.	*Empirical literature on research funding; (post)doctoral education*	Research funding is positively related to the volume of research.	n/a
Jacob and Lefgren (2011b)	18,135 applicants for NIH grants, multidisciplinary	Longitudinal. Regression discontinuity design, control for past performance. Uses HR data, bibliometric data.	*Empirical literature on research funding*	Impact of NIH grants on research productivity is gender, discipline, and context specific. The grants have a greater impact on the research output of researchers under the age of 45 compared with older researchers. The grants have a significantly greater impact on researchers in the biological sciences than on those in the physical or social sciences. The impact of NIH funding is greater among researchers based in hospitals relative to those based in universities or research institutes.	n/a
Kahn and MacGarvie (2016)	498 foreign-born scientists who received PhDs from US universities	Longitudinal. Bias-corrected matching, 2SLS. Uses CV data, bibliometric data.	*Economics of science; economic geography*	Scientists' location outside the US has a negative impact on the volume of publications, except for cases when the country of location has high GDP per capita.	Location outside the US has a negative impact on the scholarly impact, except for the cases when the country of location has high GDP per capita.
Kelchtermans and Veugelers (2011)*	1036 scientists in biomedical and exact sciences in 1 university in Belgium	Longitudinal. Control for individual fixed effects and past performance. Uses HR data, bibliometric data.	*Sociology of science; knowledge networks; literature on the role of gender in academic careers; empirical literature on research funding; literature on research-teaching-admin nexus*	Having access to research funding is positively related to the volume of research (except for top researchers).	Having access to research funding is positively related to scholarly impact. Patenting has a small positive effect on scholarly impact, but only for top researchers. Teaching has a negative effect on scholarly impact, but only for top researchers.
Kim et al. (2011)	6938 academics in the US	Cross-sectional. Control for endogeneity through selectivity of doctoral origin. Uses survey data.	*Human capital; two-factor theory of motivation*	Higher number of international colleagues has a positive relationship on the volume of research for US-born and US-educated faculty members, but not for overseas-born faculty members with doctorates from other countries. Faculty's satisfaction with autonomy, intellectual challenge and responsibility is positively related to the volume of research.	n/a
Kivlighan (2008)	275 doctoral graduates of an education	Cross-sectional. Control for endogeneity through GRE	*Group composition and dynamics; stereotype threat*	Increased racial diversity within a doctoral program is	n/a

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Table A1 (*continued*)

Authors (year)	Sample	Research design/method to ensure causality/data source	Key theoretical framework (s)/literature streams used	Key findings (volume of research)	Key findings (scholarly impact of research)
	department in 1 US university	scores. Uses HR data, bibliometric data.	*literature; (post)doctoral education*	positively related to the volume of research of African American and International graduates, but unrelated to research performance of graduates from other racial groups.	
Long and McGinnis (1981) *	557 US biochemistry scientists	Longitudinal. Control for past performance and a number of instruments. Uses CV data, bibliometric data.	*Sociology of science; academic careers*	Within three to six years of employment, a scientist's volume of research conforms with the characteristics of the context, independent of prior productivity.	Within three to six years of employment, a scientist's scholarly impact conforms with the characteristics of the context, independent of prior productivity.
Mali et al. (2017)	12,164 Slovenian researchers, multidisciplinary	Cross-sectional. Two part model design. Uses HR data, bibliometric data.	*Empirical literature on research funding; knowledge networks*	Fragmentation of funding is negatively related to research excellence (publications in top outlets).	n/a
Mamun and Rahman (2016)	63 academics in Australia	Cross-sectional. 2SLS. Uses survey data.	*Role of communication technology in knowledge outcomes*	Academics' use of the Internet for scientific purposes is positively related to the volume of research.	n/a
Murayama et al. (2015)	2329 academics in US and 2081 academics in Japan (science and technology)	Cross-sectional. 2SLS, metrics of past performance. Uses survey data.	*Economics of science; sociology of science; group composition and dynamics*	Separation of the roles of research manager and scientist is positively related to the volume of research. This effect is more pronounced for larger research teams.	Integration of the roles of research manager and scientist supports serendipity, which leads to higher scholarly impact.
Muschallik and Pull (2016)	368 researchers in business and economics in Austria, Germany, and Switzerland	Lagged design (DV measured repeatedly). Control for past performance, CEM. Uses HR data, survey data.	*Human capital; knowledge networks; mentoring*	Participation in formal mentoring programs is positively related to the visibility-weighted volume of research. The same is not true for informal mentoring.	n/a
Nag et al. (2013)	720 bioscience researchers in the US	Cross-sectional. Instrumental variables, simultaneous modeling. Uses survey data.	*Economics of science; empirical literature on research funding*	Research funding is positively related to the volume of research. Number of graduate students/postdocs in a lab increases the volume of research. Investment in human resources is more efficient than investment in equipment and supplies. An average bioscience lab overinvests into equipment and underinvests into labor.	n/a
Neri and Rogers (2013)	All academics at the level of Lecturer and above in 28 research-active economics departments in Australia	Cross-sectional. Instrumental variables. Uses CV data, bibliometric data.	*Human capital; knowledge networks; economics of science*	Human capital of colleagues (measured as the quality of their PhD) has a positive effect on the volume of research.	n/a
Pfeffer and Langton (1993)	19,989 faculty members in more than 600 US academic departments	Lagged design (DV measured repeatedly). Control past performance. Uses survey data.	*Reward structures; equity and distributive justice*	Pay-for-performance salary regime is positively related to the volume of research. Wage dispersion within department is negatively related to the volume of research.	n/a
Prager et al. (2015)	1844 US agricultural and life science faculty (sub-sample for longitudinal part – 147 faculty).	Longitudinal and cross-sectional (two separate datasets). Control for past performance. Uses survey data.	*Economics of science; literature on research-teaching-admin nexus; role of communication technology in knowledge outcomes*	Time spent on admin and on grant applications reduces time available for research, which negatively influences the volume of research.	n/a
Ross et al. (2016)	134 postdocs in psychobiology in 1 US university	Lagged design (DV measured repeatedly). Control for past performance. Uses bibliometric data.	*(Post)doctoral education*	Change from sequential model of postdoc training (where postdocs gradually built skills and then applied them to a research project) to concurrent model of postdoc training (where postdocs worked on a research project and built skills along the way) increases the volume of research.	n/a

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Table A1 (*continued*)

Authors (year)	Sample	Research design/method to ensure causality/data source	Key theoretical framework (s)/literature streams used	Key findings (volume of research)	Key findings (scholarly impact of research)
Ryazanova and McNamara (2016)*	500 academics from top US business schools	Cross-sectional. Heckman's procedure. Uses CV data, bibliometric data.	*Sociology of science; knowledge networks; academic careers; (post)doctoral education*	Research visibility of organizational environment has a positive impact on the volume of research. Doctoral program's orientation toward top journals has a negative effect on the volume of research.	Research visibility of organizational environment and doctoral program's orientation toward top journals has a positive effect on scholarly impact. This impact is stronger than the impact on the volume of research.
Shibayama (2019)	162 supervisors and their 791 PhD students in life science labs in Japanese universities	Longitudinal and cross-sectional (two separate datasets). PSM and control for rank of undergraduate degree. Uses survey data, CV data, and bibliometric data.	*(Post)doctoral education; academic careers; task autonomy; exploration and exploitation*	More autonomous approach to doctoral training increases students' volume of research in the long term but decreases it in the short term. Exploratory training (new research field) reduces the number of joint publications with a supervisor.	n/a
Slavova et al. (2016)	94 US academic departments in chemical engineering	Longitudinal. Control for past performance and department-level selection. Uses CV data, bibliometric data.	*Learning theory; social comparison theory*	Research visibility of newly hired faculty members has a positive effect on top journal publications of existing faculty members with short tenure and a negative effect on top journal publications of existing faculty members with long tenure. This effect is weaker for departments with high heterogeneity of expertise and stronger for departments with a strong internal collaboration culture.	Research visibility of newly hired faculty members has a positive effect on scholarly impact of existing faculty members with short tenure and a negative effect on scholarly impact of existing faculty members with long tenure. This effect is weaker for departments with high heterogeneity of expertise and stronger for departments with a strong internal collaboration culture.
Smeby and Try (2005)	1811 faculty members in Norway's 4 universities and 3 specialized universities, multidisciplinary	Cross-sectional. Control for fixed effects, attempts to address causality issues. Uses survey data.	*Sociology of science; peer effects*	A climate of cooperation at departmental level has a positive impact on the volume of research. Innovating climate in the department has a negative impact on the volume of research.	n/a
Tahmooresnejad and Beaudry (2015)	4886 nanotechnology scientists in Canada (1164 in Quebec and 3722 in other provinces)	Longitudinal. Instrumental variables, 2SRI. Uses HR data, bibliometric data.	*Empirical literature on research funding*	Public funding is positively related to the volume of research, with diminishing returns.	Public funding is positively related to the scholarly impact for nanotechnology scientists in Quebec, but not in other provinces.
Tahmooresnejad and Beaudry (2019)	1701 nanotechnology scientists in Quebec	Longitudinal. PSM, continuous treatment model, control for past performance. Uses bibliometric data.	*Empirical literature on research funding*	n/a	Public funding has an inverted U-shaped relationship with scholarly impact, and private funding has a negative effect on scholarly impact.
(Taylor et al., 2006)	715 academic economists in the US	Cross-sectional. Control for past performance, sub-sample analysis. Uses survey data, bibliometric data	*Economics of science*	Teaching load and service load are negatively related to the volume of research.	n/a

n/a – refers to the case where a specific paper has not tested a particular outcome variable (volume or impact).
Papers marked with * are classified as "high confidence" in relation to their causal claims.
DV – dependent variable. PSM – Propensity score matching. 2SLS – two stage least squares. GMM – generalizes method of moments. 2SRI – two stage residual inclusion. CEM – coarsened exact matching, LES – linear endogenous switching.

embeddedness of researchers cannot be resolved by choosing one perspective over another, because both are meaningful in predicting research outcomes (Ryazanova and McNamara, 2016). Instead, we need to integrate these two perspectives in a more robust and consistent manner.

Methodologically, we need to move to multi-level research designs. These designs should go beyond the relatively simple control for organizational-level fixed effects and include a theory-driven exploration of organizational and group-level processes that, alongside individual predictors, influence different aspects of individual research performance. Conceptually, we need to pay attention not just to the way in which teams affect individuals (Kivlighan, 2008; Smeby and Try, 2005), but also to the way in which individuals affect teams (e.g., Aguinis and O'Boyle Jr., 2014; Groysberg et al., 2011). This focus on reciprocal relationship, combined with longitudinal research designs, has a potential to deliver useful insights into the dynamics of individual research performance.

We also need to fully leverage the concept of task environment as an important moderator of individual motivation and ability to deliver performance (Ployhart and Moliterno, 2011). For example, existing research on scientific communication can be advanced by integrating geographical dimension into the study of long-distance co-authorships. Future studies could examine these co-authorships on a scale from having a co-author at a different institution in the same city, to a co-author in a different city, to a co-author in a different country. Such studies, applying research on virtual teams (e.g., Zimmermann, 2011) to academic context, could identify whether there is a 'sweet spot' between the benefits of internationally distributed research teams and the challenges of communication across time zones. Qualitative studies could also explore how work is allocated and managed in more successful academic long-distance research collaborations. The evidence from these studies could inform researchers' career decisions and help faculty manage complexity in their research activities.

While the literature we reviewed agrees on the importance of financial and IT resources, it does not offer specific insights in relation to the role of physical environment in supporting research productivity. Yet, anecdotal evidence from academic life confirms that the allocation of office space is one of the most contested operational issues in universities (e.g., Thaler, 2015). In addition, recent research demonstrated key importance of physical capital (in particular, specialized physical capital) in lab sciences (Baruffaldi and Gaessler, 2021). While the importance of specialized equipment might vary across disciplines, the literature also highlights the general benefits of physical co-location of researchers, which include higher creativity (Heinze et al., 2009), knowledge spillovers (Bosquet and Combes, 2017), and professional network formation (Brass et al., 2004). However, the question of working remotely is becoming more salient, partly as one of the initiatives for improving equality and diversity in academia, and partly as a response to the growth of online education. Remote work is also part of global conversation on the ways to reduce carbon footprint of all industries, because it allows organizations to decrease emissions from employees commuting to the offices.

Evidence from industry press reveals the tensions between estate management departments of universities and individual academics. The former consider empty faculty offices the hallmark of inefficiency, given the increasing price of land and premises. The latter find an obligation to be constantly present on campus (and available to interact with students and colleagues) irksome and detrimental to their ability to concentrate on research (McKie, 2019). A popular solution offered by other sectors to part-time workers – an open plan office with 'hot desks' – has not delivered on its promise to increase creativity and collaboration in private sector (e.g., Bernstein and Waber, 2019) and is unlikely to be more beneficial in academia. To make the case in favor of any specific configuration of physical environment, we need studies that interrogate evidence from different office/remote office arrangements and their influence on research productivity. These studies could draw upon existing research on remote work (e.g., De Menezes and Kelliher, 2011; Nakrošienė et al., 2019) and organizational spaces (e.g., Taylor and Spicer, 2007).

4.3. Assumptions about the nature of academic work

One way to reduce the tension between the need to cater to the interests of academic and non-academic stakeholders is to adopt a "pluralistic conceptualization" of impact (Aguinis et al., 2014, 2021), which would include scientific performance (volume and citations) and engagement with practice (directly or through teaching) under a broad umbrella of scholarly impact. To enable this reconceptualization of impact, we need to bring the state of measurement for practice-oriented outcomes to the same level of development as the one that currently exists for scientific performance. Some progress has been achieved, for example, in developing a scale that can be used to measure knowledge spillovers from academia to practitioners (Prado-Gasco et al., 2020), but more remains to be done.

The broader conceptualization of impact, if adopted in hiring and promotion policies, should influence career scripts (Laudel et al., 2019), increasing faculty's motivation to engage in different types of impactful activities. In order to support this motivation with resources, we need to have a better understanding of bottleneck resources which drive the trade-offs in the behavior of researchers. Our reviewed studies demonstrated that one such resources is time. Evidence from other streams of literature indicate that social capital and industry-related experience could also be driving decisions to focus on different types of impact (Hmieleski and Powell, 2018).

Finally, exploring the strategies and structures which could enable synergies between different types of impact is a promising way to find a middle ground between different dimensions of academic institutions' mission. An example of such strategy in our review is the involvement of both undergraduate and graduate students in research activities (Horta et al., 2012). Sauermann and Stephan (2013) also demonstrated that academic and industrial science share many similarities, which opens opportunities for collaboration and convergence in objectives. Future research might explore how consulting, entrepreneurial or technology commercialization activities can be undertaken in ways which are more complementary to traditional scientific work, and what resource allocation and structural choices could support such synergies. The conceptual foundations for this research can be found in the discussions of academic rigor versus relevance gap, as reviewed by Kieser et al. (2015).

4.4. Mechanisms behind individual research production: selection versus development

The choice of strategies focusing on the selection rather than the development of productive researchers is often rooted in the nature versus nurture logic. Prior research shows that individual characteristics remain one of the strongest predictors of individual research performance (e.g., Bosquet and Combes, 2017), so it is easy to interpret lower performance as the sign of the lack of ability and/or motivation to do research. This logic, however, omits the role of cumulative advantage mechanisms which reinforce the productivity of some academics while excluding others from sources of research support. These mechanisms are discussed in the literature on the Matthew effect (Bedeian et al., 2010; Merton, 1968): The Matthew effect results in a relatively small cohort of already successful academics having the lion's share of resources, while a larger cohort of researchers who have not yet achieved success have to compete for a smaller share of the pot.

Cumulative advantage mechanisms are rooted in difficult trade-offs made by research leaders and academic administrators in resource allocation. Within the context of research funding, the chance of a PI receiving a grant is strongly correlated with their past success in securing research funding (e.g., Nag et al., 2013). In order to acquire this funding experience in the first place, potential PIs must join existing research groups led by more senior PIs, which limits junior researchers' autonomy and leads to conflicts over credit (Floyd et al., 1994). Yet, from the funders' point of view, allocating money to a PI without a proven track record increases the risk of wasting taxpayers' money.

Concerning resource allocation by academic leaders to support research performance, it is likely that the positive relationship between teaching graduate classes and research productivity (Horta et al., 2012) hides another manifestation of the Matthew effect. Highly productive academics tend to have better access to graduate research students because it is in the interests of academic leaders to structure teaching allocations in a way that facilitates research productivity. Even if highly productive academics are teaching the same number of hours as their less productive colleagues, more research is likely to come out of teaching doctoral seminars (especially those where each student has to write a working paper as part of the course assessment) than undergraduate classes.

The trade-off that academic leaders face here can also be examined through the lens of short-term vs. long-term research outcomes. To achieve short-term outcomes, it makes more sense to invest resources into supporting faculty who have already built their research capacity and can successfully exploit it for the benefit of the institution. By creating a disproportionally large share of value, these productive researchers might feel that they have earned the right to idiosyncratic deals (Aguinis and O'Boyle, 2014) and might become demotivated if their efforts are not rewarded accordingly. In the long term, however, these idiosyncratic deals might lead to segregation of faculty staff into a small core of research "stars" and a large population of academics who are demotivated by wage dispersion (Pfeffer and Langton, 1993) and who struggle to keep their research going. The loss of any individual from the research core exposes the institution to the risk of a significant decrease in research performance and, consequently, a drop in rankings. Yet, these research "stars" are becoming attractive targets for employee poaching by competitors, which means that the institution needs to dedicate an increasing amount of resources to their retention.

To understand the price of choosing selection over development, we need to explore both the positive aspects (such as specialization and programmatic research) and the negative aspects (such as increased stratification and social exclusion) of path dependence in academic careers. From the methodological point of view, this can be achieved by a wider use of longitudinal research designs (to track short-term and long-term effects of events and actions) and mixed methods approaches (to understand what happens in academic careers and why it happens). There is some evidence in our review that conscious efforts to achieve a more balanced allocation of resources delivers positive outcomes for previously disadvantaged groups of researchers (e.g., Aboal and Vairo, 2018; Ding et al., 2010). To ensure that these efforts are efficient, we need to understand what critical junctures in academic careers block some groups of researchers from progressing towards high performance. Existing research can provide insights into some of those junctures, such as the choice of a PhD program (Bedeian et al., 2010), securing first full-time faculty job (Miller et al., 2005), meeting the requirements of tenure (Glick et al., 2007), and mobility choices (Ryazanova and McNamara, 2019). The long-term performance consequences of other junctions, such a becoming a PI or accepting a high-level administrative position within an institution, received less attention and require further exploration. A useful conceptual angle here might be to treat these junctures as types of career shocks (Kraimer et al., 2019), which influence different aspects of academic career success.

5. Implications for practice

5.1. Matching resources and outcomes

The evidence shows that academic leaders should go beyond the task of ensuring that research activities are well resourced and match desired research outcomes with appropriate types of resources. Some types of applied research outcomes benefit from the combination of public and industry funding, but for other types of research the proportion of industry funding should not exceed one third. In addition, higher volume of grant money (something which is usually considered to be a desirable outcome in academia) might not translate into higher volume and scholarly impact of research if it comes with the price of funding fragmentation and large time investments.

In making resource allocation decisions, it is also important to consider whether the preference is given to the short-term or to the long-term research outcomes. For the former, it makes sense to concentrate resources and allocate them to the most productive scholars in order to further support their performance. For the latter, it makes more sense to allocate smaller amounts of resources to a broader range of researchers, with the objective to develop research capacity of a larger and more diverse cohort of scientists, given that diversity has been shown to positively influence knowledge creation, at least in the countries with low power distance (Van der Vegt et al., 2005).

5.2. Managing benefits and costs of structural choices

Structural choices can be powerful mechanisms influencing individual performance outcomes, but in implementing those choices academic leaders should consider costs as well as benefits. For example, at the doctoral training level, institutions face a trade-off between short-term and long-term performance outcomes of the graduates. In order to achieve higher volume of research in the short term, the autonomy of doctoral students needs to be reduced by engaging them in the ongoing projects of a specialized research team from the early stages of their training, so that they can learn by doing, and produce some tangible research outputs by the time they graduate. This approach seems to be aligned with job-market expectations, which requires publication as proof of research capability. The downside of this approach is lower long-term volume of research and, potentially, missed opportunities for developing radically novel ideas that drive scientific fields toward new frontiers of knowledge. If policymakers want doctoral students to pursue high risk and high reward ideas, job-market aspirations need to be adjusted to allow for a longer time to publication for graduates and early-career scholars. Institutions should also provide incentives for faculty who supervise these students as it is less likely that these supervisors will be rewarded by joint publication with their students. Currently, in many institutions, PhD and postdoc supervision is not considered part of the faculty's teaching load, on the implicit assumption that supervisees dedicate substantial time to assisting supervisors with their research.

At the faculty level, the development of existing faculty can be effectively supported by implementing formal mentoring schemes. Mentoring, however, requires a time investment from mentors – time investment which is not usually rewarded through promotion, status or any other means. Therefore, appropriate incentives should be introduced to give mentors credit for nurturing the research productivity of their colleagues.

5.3. Creating pluralistic research cultures

If institutions want to serve multiple groups of stakeholders through faculty research activities, they need to create pluralistic research cultures that align with the pluralistic understanding of scholars' impact. As long as traditional scientific performance (volume and citations) remains the most important metric in hiring and promotion, this creates strong disincentives for researchers to use their scarce time resource for engaging with nonacademic stakeholders. This is particularly challenging for those with caring responsibilities, who cannot continually extend their workday to accommodate additional demands and maintain high levels of contribution to science. One of the first steps towards pluralistic research cultures should be the introduction of multiple career tracks, based on different sets of criteria, for example, teaching excellence or engagement with industry. Such tracks already exist in some institutions; however, a broader adoption and legitimization of different types of career scripts would add more flexibility to academic careers and help institutions provide a more balanced value proposition to their multiple stakeholders. In the absence of a pluralistic research culture, any additional resource allocation will be channeled by researchers towards higher scientific performance rather than a broader research impact.

Even within the traditional mission of creating knowledge for science, the evidence shows that volume and the scholarly impact can emerge from different behaviors and there are trade-offs involved in developing one aspect of research performance over another. This means that, in hiring and promotion of researchers, it would be unreasonable to treat these metrics in a simple additive manner. Research performance has a highly skewed distribution, and at the extreme end of this distribution, research stars have both high volume and high scholarly impact of research. For the majority of researchers, however, it is more reasonable to expect either orientation towards high volume or the orientation towards high scholarly impact. In making hiring and promotion decisions, academic managers should examine the alignment of different metrics with the institutional strategy (for example, by looking at the methodology of the rankings in which an institution seeks to have a strong position), and clearly communicate the expectations to the employees.

5.4. Designing task environments for academic work

Institutions need to put a more conscious effort into designing task environments that support research. Traditional approach to this includes the investment in scientific equipment and facilities; however, evidence shows that human capital makes a more important contribution to research outcomes than equipment. In creating conditions where human capital can realize its potential, institutions need to balance the scientists need for frequent face-to-face communication and their need for uninterrupted research time.

The need for communication can be supported by designing physical environment on campuses which facilitates serendipitous conversations between researchers from the same or, even better, from different disciplines (Heinze et al., 2009). Communication with external collaborators can also be vitally important for building research capacity, especially when research skills and training are not available in-house. To support such communication, another productive policy would be to increase funding for sabbaticals, research visits, and conference travel. While a research presentation can be delivered online, the informal and spontaneous element of face-to-face communication with the research community at a conference is difficult to replicate through the computer-enabled medium. The institutions should also collect regularly data to assess the relative value of small research gatherings versus large events, and review their conference funding policies accordingly. The need for uninterrupted research time should be supported by reasonable student communication policies and the availability of quiet private spaces on campus where researchers could focus on scientific work and, potentially, achieve the state of flow (Csikszentmihalyi, 2002), which is conducive to individual creativity.

6. Limitations and conclusions

Our review has revealed some nuances related to the trade-offs between volume and scholarly impact, but there is more to be done in this space. For example, the nature of contribution to research performance might change throughout academic careers, with early career researchers more engaged in publishing papers and senior scholars focused on securing funding for their research groups. While for the former it would be appropriate to measure performance through publications, the latter's contribution to research might be more appropriately measured by the number and size of grants which they won as PIs. Future studies of the management of research performance would benefit from being sensitive to the specifics of academic career stages.

To conclude, in this review we synthesized empirical evidence on individual research performance management, offering decision makers in academic institutions actionable insights on how they can use key managerial leverages to support the production of research outcomes. We also highlighted conceptual weaknesses, contradictions and divergent approaches in the literature, offering directions for future research which could result in a deeper and more cohesive body of knowledge on how organizations, funding bodies, and government agencies can influence scientific performance at the individual level.

In addition to its contributions to the development of the study of science and to the practice of managing research in academic institutions, our review sought to inform academics making intra- and inter-organizational mobility choices. For those moving into roles where they have to connect resources and research outcomes (such as the role of research center director, research director, or research vice-chancellor), we provided a lens for identifying the most critical factors that need to be managed in order to improve research performance in a particular institution. Knowing the most important strengths and weaknesses of their research environment, incoming research leaders can make appropriate resource claims early in their tenure, setting the correct trajectory for future initiatives. For early-career academic job-seekers who strive to excel in research but have no control over the features of their potential employers' research environment, we offered evidence-based insights to help them select a workplace that will best support their research efforts. In a pragmatic sense, knowing which factors are responsible for increased research performance helps potential employees ask pertinent questions during job interviews or campus visits, and guides their search for relevant secondary information about potential workplaces.

CRediT authorship contribution statement

Olga Ryazanova: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Project administration. **Jolanta Jaskiene:** Conceptualization, Methodology, Formal analysis, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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