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6 Dynamics of Academic Leadership

In this study, we have investigated the dynamics of academic leadership and how this influences performance of research groups. Academic leadership is defined as the management and leadership of researchers and the research group; it refers to a variety of opinions, tasks and practices of academic group leaders. Four components of academic leadership were distinguished in the literature. (i) Leadership in a strict sense is the way researchers are directed and stimulated by the vision and inspiration of the leader. (ii) Group management concerns the tools that are used to manage the research process. (iii) Network management covers the activities undertaken to position the research group in the academic and societal environment to obtain legitimacy, reputation and visibility. (iv) Finally, resource strategy is the task to acquire and combine resources for the group.

In this final chapter I will summarise the conclusions of the four studies. Subsequently, I will discuss the theoretical implications that follow from the main conclusions, and examine their contribution to a theoretical framework. The model as presented in chapter three – explaining how academic leadership influences research performance – will be adjusted as well as extended. The new model brings forth a hypothesis on how research performance is also affected by internal group dynamics and by higher level management. Finally, science policy implications concerning the organisation of research groups and research evaluation will be discussed.

1. Conclusions

1.1 Characteristics of leaders of high-performing and weak-performing groups

In the second chapter, the differences in academic leadership between leaders of high-performing and other research groups was investigated. It appeared that leaders of high-performing groups can be characterised as all-rounders. They set the example by showing strong research commitment. In comparison with the other group leaders, they behave more like co-researchers than managers, they consider themselves as highly-skilled scientists, set high level quality standards, are less distracted by non-research tasks and have a higher proportion of PhD students. Leaders of high-performing groups are also more devoted to group management compared to the other group leaders. They organise internal communication more frequently and provide more opportunities for researchers who are free to bring up individual research interests. In addition to internal management tasks, they put more effort into network management than the other group leaders. They pay relatively much attention to gaining visibility and reputation (i.e. by visiting conferences and participating in assessment committees) and to obtaining resources from various sources – especially from competitive funding agencies.

Finally, the issue of weak-performing groups was addressed. The findings suggest that weak performance is a characteristic of less experienced group leaders. That is why the third chapter focuses on the characteristics of academic leaders and the changes over time.

1.2 Characteristics of academic leaders

More specifically, the third chapter examined how generation and life cycle influence academic leadership. Generation is defined by the year a PhD is obtained (PhD cohort membership). Life cycle phase refers to the years of experience as group leader (less experienced, experienced or departing group leaders). Both generation and life cycle phase influence the behaviour of academic group leaders. Two generations of academic group leaders were defined on the basis of environmental changes in the Dutch science system; these changes are the institutionalisation of research evaluation and the growth of project funding, both during the mid-1980s. The two generations have been socialised into the academic world in two different time periods. It was hypothesised that this would be reflected in their academic leadership practices. The study supported this. The younger generation of group leaders spent more time on research activities and group management but less on education. The younger generation had a higher proportion of external funding from more various sources and had a lower proportion of permanent staff. And, when it came to setting the agenda, they considered the prospects and interests of PhDs less important than the older generation did.

With regard to life cycle, it was hypothesised that academic leaders at different stages of their careers have different goals, interests and responsibilities that are reflected in their leadership behaviour. The starting group leaders (with 5 years or less of experience) still need to build up a reputation and this results in lower network activity; they need more time to get visibility. They less often motivate researchers with intangible rewards. Finally, they give high priority to raising creative research themes; this might be their main strategy for setting a reputation. Experienced group leaders (with more than 5 years of experience) need to retain their reputation through the preservation and improvement of group vitality; consequently, their highest priority is to acquire new research funds. They have a higher proportion of external funds, but they are also more active in submitting research proposals to the medical research council, and they attach more value to the quality control of research proposals submitted by their group members. The nearly departing group leaders (57 or older, near retirement) tend to reduce their research activities in preparation for their departure as group leaders. They spend less time on research activities and group management and consider visibility in top journals less important. However, their coaching and educational role increases as they spend more time on education. The older research leaders more often emphasise that PhD students should have the chance to follow their own interests and define their own research themes.

Academic leadership strategies and research goals

The fourth chapter introduced a conceptual model of the relationship between academic leadership and research performance. This model is based on the two preceding chapters, on Gladstein's (1984) inputs-process-outputs model of group effectiveness, and on the resource dependence theory (Pfeffer & Salancik, 1978). The model was tested to answer the question how various academic leadership practices simultaneously influence research performance. In general, it was concluded that the research goals that a group aims to achieve (achieving high output, securing high visibility, achieving high productivity and attaining high quality) determine the strategy that the group should follow.

Different goals call for different leadership strategies. To be precise, the higher the proportion of PhD students and the more time spent on network activities, the higher the output, visibility and productivity will be. To raise quality (indicated by a high number of citations per publication), however, one needs other instruments: a quality-minded leader who spends a relatively large amount of time on research. High visibility requires leaders who regard themselves more as co-researchers than as managers, and a higher proportion of senior researchers. On the other hand, high output calls for leaders who consider themselves high-skilled scientists. In comparisons with the leadership role, management is a side issue for achieving high research performance. Performance is not affected by management practices; rewards and the degree of communication and quality control do not seem to matter.

Different goals also call for different resources. Increasing group size raises output and visibility, but lowers average productivity as a result of diminishing marginal returns on labour. Diversity in funding sources is beneficial for gaining visibility and quality.

1.3 Towards broader research goals

Chapter five explored the societal orientation of academic leaders and investigated how societal and scientific productivity are related. It appeared that, on average, academic leaders look favourably on the societal orientation of their research agenda, their communication with stakeholders, the degree of knowledge dissemination to stakeholders and the generation of a wide diversity of societal output. Nevertheless, a positive view towards societal orientation does not automatically generate more societal output. Moreover, leaders are not used to reporting the amount of societal output. This is not surprising, since measurement of societal output is not implemented in the research evaluation system to the same extent as scientific output is.

The three medical disciplines (i.e. para-clinical, pre-clinical and clinical) differ in societal orientation and output; para-clinical groups are most active and productive in generating societal output. They are followed by clinical groups. Pre-clinical groups are the least societally oriented and productive ones and

they have slightly more neutral views towards societal orientation, too. Yet, pre-clinical research groups – as shown in the virology case – seem to disseminate new knowledge to stakeholders via scholarly output. It seems that pre-clinical groups express their societal orientation indirectly through contributing to the stock of knowledge, instead of directly via measurable societal output on a group level. However, some of the pre-clinical groups contribute in a more direct way to knowledge transfer, by spending time on patient care – through translational research – and they are also more active in generating societal output. Apparently, translational research stimulates a societal orientation.

Scientific and societal productivity are not correlated. This suggests that specific incentives are required to stimulate societal research output, and that societal relevance is not simply the result of policies that stimulate high scientific quality.

1.4 Taking it altogether

The four empirical studies together are an attempt to answer the research question: how does academic leadership influence performance of research groups? Two key factors can be indicated that influence the performance of research groups positively. Leadership turns out to be crucial for achieving high performance. Academic leaders set the example by showing strong research commitment and determining the quality standard. As explained by one of the experts interviewees:

“If you are confronted with excellence, [as when you are at] a good conference, then you improve yourself, as well [as when you have] a good work discussion with sharp people, where people can think laterally, which makes the group think laterally. It’s really like skating behind someone. If you’re riding a lap and you scratch and scrape, and then you ride behind someone and it goes so much smoother, what has changed for you? Yes, nothing, but you have a good example and you’re obviously doing what is right. When you are making music together with someone who plays very well, you start playing better yourself, but when he is gone then... That incubation of talent and the incubation of the above-average [is what] makes people perform better without you even adding something.”

The other key factor is network management. It concerns the way in which academic leaders position their group in the scientific and societal environment and how they respond to environmental opportunities and constraints. On the one hand, network management refers to obtaining resources from a wide variety of external sources (especially competitive funds)-that increase autonomy and human capital (especially PhD students). On the other hand, network management refers to gaining visibility and a reputation through i.e. conference attendance and committee membership.

Furthermore, the production of societal output also seems to depend on network management. In fact, neither leaders’ attitudes towards societal orientation nor

their scientific productivity are related to the generation of societal output. It is the way they respond to the requirements and incentives from funding agencies that determines their activities and productivity in societal output. One of the expert interviewees explains why scientific and societal collaboration is necessary and what it creates.

“The days are gone when you could stand in your lab as a loner and do a few experiments. It has all become so multidisciplinary that you are always dependent on other people; you can hardly do anything by yourself. In technological or clinical research you must always collaborate. People who want to do everything completely on their own do not fit in this society anymore, because it has become far too complex. [...] You can see it growing in the Netherlands, that it can have much added value when you bundle research, when you ensure you do not compete with each other but stimulate cutting-edge research. [...] I regularly give talks for patients, through the patients association, because they want to know what we are doing and if there is anything we can do for them, that’s a nice spin-off. [...] In a consortium your work becomes more visible, but it also works the other way around, because the moment your patients’ association commits itself to us, it becomes easier to get access to patients. If you want to do a study and you say that it is being done within the consortium, patients know what you’re talking about. And that means you can reach people and ask them if they want to cooperate with research. That works really well and it works both ways.”

Thus, the main factors that influence performance of research groups are leadership and network management. However, research performance is indirectly influenced by characteristics of academic leaders, such as experience, age and (generational) cohort membership.

2. Theoretical implications and further research questions

Previous studies have shown the importance of academic leadership in order to create the right conditions for achieving individual and collective research goals, such as high research performance (Amabile et al., 2004; Andrews, 1979b; Babu & Sing, 1998; Bland & Ruffin, 1992; Goodall, 2009; Harvey et al., 2002; Knorr & Mittermeir, 1980; Omta, 1995; Omta & De Leeuw, 1997; Pelz & Andrews, 1966; Stankiewicz, 1976; Van der Weijden, 2007; Van der Weijden et al., 2008). These and other empirical studies identified various determinants for a productive research environment, including human and financial resources, intangible rewards, research communication, quality control, motivation, international communication and collaboration, and experience of the group leader. These determinants refer to different tasks, practices and opinions of academic leaders that create the optimal research environment for research groups.

In most of the empirical studies, only one or a few of these factors were included. This study, however, elaborates on earlier work of Van der Weijden

(2007; 2008), who conducted one of the few studies that does examine a wider set of academic leadership determinants of research performance¹. The study concluded that group leaders have different (combinations of) research goals and each research goal calls for a different strategy. Van der Weijden's study shows the complexity of steering a research group. Other bivariate studies show similar effects. My study, however, takes a next step and tries to disentangle how different academic leadership practices are interrelated and how they simultaneously influence research performance.

Previous studies on the relationship between academic leadership and research performance are empirically rather than theoretically driven. My study is a first effort to explain, within a theoretical framework, the mechanisms behind the connection between academic leadership and research performance. As a first contribution, based on a literature review, academic leadership was defined as the management and leadership of researchers and research groups (presented in chapter two). The various determinants of academic leadership were classified into four comprehensive components:

- Resource strategy: acquiring and combining (financial and human) resources;
- Leadership: steering researchers through inspiration and vision;
- Group management: managing and coordinating the research process, and
- Network management: obtaining legitimacy, a reputation, and visibility in the academic and societal environments.

Subsequently, a conceptual model was presented in chapter four. This model was based on previous empirical results (including chapters two and three of this study); on Gladstein's inputs-process-outputs model of group effectiveness (1984); and on Resource Dependence Theory (Pfeffer & Salancik, 1978).

Testing the model led to the conclusion that the main factors that influence the performance of research groups are leadership (i.e. how the leader evaluates his commitment towards research and his attitude to quality) and network management (i.e. activities of the leader in the scientific community as well as the ways of acquiring external funding and recruiting human resources). Management is strongly correlated to leadership and therefore has no additional effect on research performance (see also chapter two). Characteristics of the leader (age and experience) seem to influence research performance indirectly via academic leadership (chapter three): less experience leads to less network activity and a lower percentage of PhD students, and this in turn leads to lower performance (see also chapter two and four). Finally, the scientific discipline is the main environmental condition that influences the performance of a research group.

1 One of the first studies on this topic was conducted by Pelz & Andrews (1966).

What is the next step in understanding the relationship between academic leadership and performance of research groups? Firstly, the empirical findings of chapter five call for extending the model with societal activities (societal research goals, interaction with stakeholders and knowledge transfer to stakeholders) and societal output. It turns out that societal and scientific productivity are unrelated. Societal output is an additional dimension of research performance.

Secondly, the model should be extended with bottom-up and top-down processes. In the current model, the behaviour of the group leader is the primary determinant of the group's research performance. As suggested in the introduction, achieving high performance may not only be the result of the behaviour of academic group leaders, but it may also be influenced by bottom-up and top-down processes. Bottom-up processes concern the group dynamics; that is, how individual researchers with different competencies and activities interact with each other. Top-down processes concern conditions and constraints created at a higher organisational level, such as the management and policy practices of heads of departments, deans and boards of research organisations.

How should the model be adjusted in order to account for the effects of bottom-up and top-down processes on the performance of research groups? With regard to bottom-up processes, the question is: how we can understand the relation between group dynamics, academic leadership and research performance? This study shows that the attitude of the group leader is an important factor in achieving high performance. But is the leader's attitude converted into a group norm? According to Van Knippenberg & Hogg (2003), leaders influence their group members in an effective way because they are group member themselves. A leader can influence group members more effectively if he or she is a representative of the group's identity (prototypical leader), and if his or her behaviour is perceived by the group members to benefit the group. Hence, the conversion of the leader's research and quality commitment into a group norm depends on how the group members evaluate their leader. Yet, little is known about the communication processes between leaders and group members that can lead to the development of group norms (Hogg & Reid, 2006). As Monge and Contractor (2003) argue, various social theories are needed to understand communication processes and the emergence of communication and organisational networks. For example, communication between leaders and followers can lead to the development of group norms by physical proximity (influencing attitudes through an increase in communication because of physical closeness), by cognitive consistency (a drive towards shared attitudes) and by social learning (contagion of attitudes because of mimetic processes).

With regard to top-down processes, the question is how higher-level management, academic leadership and research performance are related. This study and previous studies have shown that higher involvement in research yields

higher research performance (i.e. Pelz, 1956; Jauch, Glueck, & Osborn, 1978; Babu & Singh, 1998). This so-called professional commitment² is reinforced when researchers receive recognition from their scientific community (Cornwall & Grimes, 1987). Professional commitment is also influenced by organisational expectations, goals, values and norms (Cornwall & Grimes, 1987; Tuma & Grimes, 1981; Schein, 1968). The influence of the organisational context can be classified under the concept of organisational commitment, which refers to an affective connection³ with the organisation (Mowday, Porter, & Steers, 1979). It means that one wants to stay in the organisation because it is the most convenient environment to achieve one's personal goals (Ashforth & Mael, 1989). Numerous studies have shown that individual research performance depends to a large extent on the organisational context. Organisations provide facilities for high performance such as contacts and equipment (Allison & Long, 1990; Crane, 1965; Keith & Babchuk, 1998; Long, 1978; Long, Allison, & McGinnis, 1979; Long & McGinnis, 1981; Ramsden, 1994; Reskin, 1979). As long as the criteria used for the distribution of rewards are perceived as legitimate and the organisation provides career opportunities, organisational commitment will be strong (Wallace, 1995). If not, the incongruence between expectations, goals, values and norms of the organisation and of the individual will probably lead to the dominance of professional commitment (Ellemers & Rink, 2005; Meyer, Becker, & Van Dick, 2006). An open question for further research is which characteristics of the organisation encourage organisational and professional commitment of academic leaders, and how these lead to research performance.

Another open question follows from the observation in this study that para-clinical groups have lower research performance and that their leaders appear to behave differently. This is in line with the observations by Reale & Seeber (2011) and De Jong et al (2011) that a different disciplinary environment requires other leadership strategies and other research goals (Reale & Seeber, 2011; De Jong et al., 2011). In view of that, it is recommended to extend this study to other research domains, such as the technical sciences or the humanities, to investigate how scientific discipline, activity profile and the mission of research groups influence the relationship between academic leadership and research performance. The new research questions have been included in the adjusted and extended model of academic leadership and research performance (figure 1).

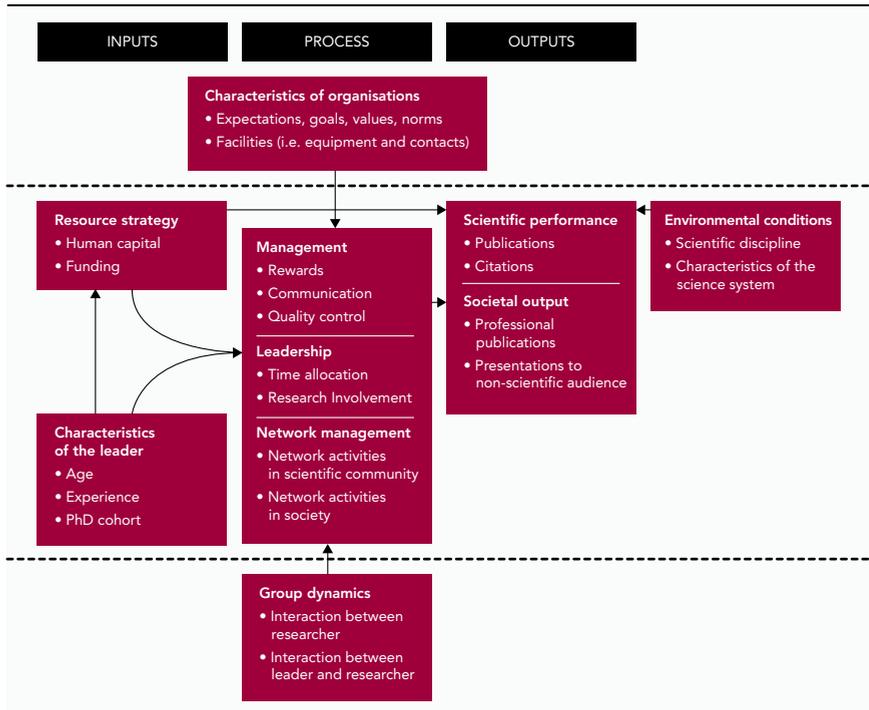
In conclusion, a multi-theoretical approach (Monge & Contractor, 2003) is needed to understand how academic leadership influences research performance. This

2 Other terms are also used for professional commitment, such as career commitment, occupational commitment, career salience and career orientation, or professional role orientations (e.g. Blau, 1988; Cornwall & Grimes, 1987).

3 Apart from being influenced by affective commitment (want to stay), the degree of organisational commitment is also determined by normative commitment (ought to stay) and continuance commitment (need to stay) (Allen & Meyer, 1990).

is no surprise: for most complex social phenomena there is not one theory that can cover all relevant mechanisms. Similarly, it is not likely that one theory only will be able to give an exhaustive explanation of which factors of academic leadership lead to high research performance, and why. This study has made a first effort in this direction.

Figure 1 Conceptual model of academic leadership and performance of research groups. Please note that more indicators of scientific performance and societal output are possible depending on the environmental conditions.



3. Science policy implications and further research questions

In this paragraph, I will combine the different science policy implications from the various empirical studies. My work has implications for the organisation of research groups and research evaluation.

3.1 The organisation of research groups

The findings of the four studies have implications for the organisation of research groups. Surprisingly, the study shows that management tools such as rewards, communication and quality control hardly seem to matter for performance. This is in contrast with earlier studies where a positive relation was found between, for example, rewards and research performance (i.e.

Omta & De Leeuw, 1997; Van der Weijden et al., 2008). Leaders cannot do without managing the research process. Yet, there is no additional effect on performance. Also, we have seen that leaders of top-performing groups put more effort into group management compared to leaders of other groups. Thus, management and leadership are strongly correlated, but apparently it is leadership that makes the difference.

There may be tension between the management of resources and processes and the leading of researchers. Management requires a well-structured organisation, while research leadership requires the kind of open and spontaneous processes that are needed to foster creative and innovative ideas. Given that the roles of academic leaders change in the course of their life cycles, one could argue in favour of bigger groups with multiple leaders who have different tasks and responsibilities. A possibility is to conduct an organisational experiment to investigate whether a group structure with multi-layered leadership – in which leadership and management tasks are divided or split up among different individuals – performs better than groups with one principal research leader. Below, you will find an explanation of how the idea of multi-layered leadership follows from this study.

With multi-layered leadership, less experienced academic leaders can be given an opportunity to explore their own creative research niche in order to set up their own research line, with the support of a more experienced group leader, who mainly secures funding for the group. This trend of increasing co-leadership in research groups can be observed in our sample: in 2002, 47 per cent of the medical research groups had a co-leader, but by 2007 this had increased to 71 per cent (Van der Weijden et al., 2009). Based on recent interviews with academic leaders, it appears that the co-leader is indeed a young person who directs his or her own research line under the management of the principal group leader. The role of highly experienced leaders who are near their retirement age should not be underestimated. In fact, though their role moves from knowledge production to education, they still spend a considerable amount of time on research and they do not lose touch with research practice. Building on many years of research experience, they can fulfil an important role in coaching the new generation of young researchers. Alternatively, they could be of value in higher management (i.e. as department heads, deans or on the board of directors), since their acquired reputation can have the power to attract talented researchers that would like to work in an organisation with such a famous researcher at its top (Goodall, 2009). This makes retirement age a discussion issue: one could think of extending the scientific careers of researchers with a change of responsibilities.

In addition to changes between academic leaders at various stages of their careers, academic leaders also differ between generations. Multi-layered leadership may offer the younger generation of researchers a faster track to

independence. This is positive for the dynamics in the science system, because the younger generation seems to be better adapted to changes in the science system. This study, for instance, shows that the younger generation of academic leaders acquires more external funds and is more productive in generating societal output.

An increase in group size has obvious consequences for coordination and management. This suggests that it may be useful to create a separate position for a research manager who can handle administrative and management tasks. The assistance of a research manager would reduce the time that academic leaders would otherwise need to spend on management issues. As a result, academic leaders could devote more time to the core activity that this study has shown to be of crucial importance for high performance: research leadership. In other words, they could be more committed and involved in conducting research. Another promising advantage of larger groups is that it can combine a variety of specialties and skills in one group, which is essential for addressing complex research problems (Börner et al., 2010; Stokols, Hall, Taylor, & Moser, 2008; Stokols, Misra, Moser, Hall, & Taylor, 2008). This might result in research groups operating in a more self-sufficient way, like small enterprises do, expanding their autonomy in relation to the university or research institute. How multi-layered leadership works in practice should be investigated in further (experimental) research.

The leader is dominant in deciding how the group responds to environmental demands (Gornitzka, 1999; Pfeffer & Salancik, 1978; Reale & Seeber, 2011). This study supports a resource-based strategy in which leaders reduce their dependency on one or a few funding sources in order to increase visibility and produce higher-quality output. However, if a research group acquires a high proportion of external funding, this is probably not always encouraged by the research organisation. Funding received from Dutch or European funding sources often does not include all overhead costs. As a result, acquiring much external funding can be quite expensive for a research organisation. The organization might even discourages their research groups from doing so. Given that acquiring funds from various external sources seems to be positive for visibility and higher-quality output, one might advocate full funding – including all research and overhead costs – of research projects from, for instance, the Dutch Research Council (NWO). In this way, research groups that acquire external funds contribute to the infrastructure costs of the organisation they belong to. A follow-up study will have to examine whether countries with full funding of research projects and those without differ in the quality of their scientific output.

Yet, when groups become less dependent on institutional funding, research institutes lose their ability to influence research groups top-down. All that is probably left for institutes to do is to recruit and select group leaders

(Strandholm, Kumar, & Subramanian, 2004). As a result, leaders develop an entrepreneurial attitude which makes them independent from the organisational environment by acquiring funds from a diverse set of sources (Etkowitz, 1998; Etkowitz & Leydesdorff, 2000; Gulbrandsen & Smeby, 2005; Hessels, 2010). This raises the question whether and how this changes the relationship between group leaders and higher level management. As researchers are generally more committed to their profession than to their organisations, organisations must find ways to commit researchers to their organization. On the other hand, academic leaders are challenged to respond to organisational demands. They can only protect their autonomy if they are able to deal with organisational conditions in an optimal way. For instance, the tendency to create 'focus and mass' at all levels of Dutch science policy (i.e. individuals, groups, organisations and government) requires academic leaders to fit their research programme into larger research themes and to participate in larger collaboration networks.

The entrepreneurial attitude may not only manifest itself in the role of group leaders, but is also expected from researchers at a much younger age. In view of the increasing dependence of researchers on funding and the greater focus in general on research, past changes in research evaluation and funding have forced researchers into a more entrepreneurial attitude. Current developments might intensify this entrepreneurial attitude. For example, new prestigious grants for talented young researchers provide opportunities for young researchers to explore their own creative research niches. At the same time, these grants may create an 'obligatory point of passage' in the route towards an academic career. A potential risk is that one loses talented researchers, as a lot of applicants who are rejected for these grants are good performers as well (Bornmann, Leydesdorff, & Van den Besselaar, 2010; Van den Besselaar & Leydesdorff, 2009). The new grant schemes which force researchers at different stages of their careers into independence possibly lead to a radicalisation of competition. How this will affect scientific careers and research leadership in the future remains an open question. But it certainly draws attention to the current trend in research organisations to institutionalise specific supervision programmes that deal with applications for such prestigious research grants. This trend might lead to a neglect of other funding sources, whereas this study shows that diversity of funding sources is good for the quality of output. In addition, the trend to apply for individual grants raises the question how, on the one hand, the independence of researchers – that these grants aim to stimulate – relates to the tendency, on the other hand, to conduct research in larger teams and collaboration networks. In other words, are individual researchers who obtain grants in order to explore their innovative ideas more difficult to manage? If Dutch career grants were based on full funding (including overheads), this might provide individual researchers with the flexibility to search for the right academic environment to set up their own research line.

3.2 Research evaluation

Our findings introduce some new perspectives on the evaluation of research groups and researchers. One of the key factors for achieving high research performance is good network management. More specifically, academic leaders need to acquire resources – including attracting PhDs to their group – and they need to be externally active, for instance at conferences and in editorial boards. Young academic leaders who have less experience also have less developed networks and, as a consequence, lower performance. This implies that the development of academic leaders at the various stages of their careers should be taken into account when evaluating research groups. Furthermore, the output of research groups is not stable over time but can be influenced by such events as the appointment of a new leader (Braam & Van den Besselaar, 2010). This calls for a more dynamic approach in evaluation assessments.

Yet, current evaluation criteria are still largely based on a narrow definition of scientific performance. The increasing emphasis on quantitative indicators of performance is raising the pressure to ‘publish or perish’ (Hessels, 2010). A stronger emphasis on rewarding publication volume will have serious consequences for other performance indicators. Research groups that adjust to higher publication norms will change their strategy, possibly to the detriment of their visibility (citations), productivity (papers per person), quality and creativity (citations per paper) because, as this study shows, these research goals require other strategies.

Only a small selection of excellent research groups has such unique qualities that they perform well on any sort of indicator. All-roundness appears to be a vital skill for leading high-performing research groups. Leaders of high-performing groups are good at acquiring resources, leading researchers, management of the research process and management of their network. Previous research by Pelz and Andrews (1966; 1979b) showed that all-roundness also positively affects the performance of individual researchers, which implies that researchers should also develop an ability to perform wide-ranging activities.

Given that research output varies along the life cycle of research groups and that different research goals (output, visibility, productivity and quality) require different strategies, it should be questioned whether a strong emphasis on evaluating publication output and impact is the right way to improve research quality. Moreover, the outcomes of research are uncertain, even in the case of excellent research. This study suggests some additional performance indicators besides the easy-to-measure bibliometric indicators. Instead of a focus on the outcomes of research, a focus on the organisation of the research process might help to improve the quality of research. In that case, the evaluation of groups should include the quality of academic leadership (such as the presence of an intensive communication structure), diversity in funding sources, group

composition (including the proportion of PhD students), research focus of the group, and intensity of network activities both in the scientific community and with societal stakeholders.

This study shows that there is a relatively strong orientation towards societal impact. This suggests that research groups can be held accountable for the effort they put into knowledge transfer to society. Leaders of research groups reported that the increased emphasis on societal impact has resulted in societal research goals, communication with stakeholders and knowledge dissemination to stakeholders. Furthermore, research groups generate a wide variety of societal output, including presentations to a non-scientific public, contributions to public media and education for professionals. Yet, neither a positive attitude towards societal relevance nor a high scientific productivity will automatically result in higher societal output or higher societal productivity. This is probably caused by the lack of incentives that might encourage a focus on societal relevance.

The findings of this study concerning the relationship between funding type and societal productivity imply that assessment criteria in funding allocation might be a strong incentive for generating societal output. To be more precise, research groups that apply for grants more often and receive more grants from the Medical and Health Research Council (ZonMw) were also more productive in generating societal output. This did not apply to other divisions of the Dutch Research Council (NWO) where our respondents applied for money, as these did not include societal relevance in selection procedures. Institutional funding correlates positively with societal productivity, which might be a result of the mission of UMCs that aim to transfer knowledge from bench to bedside. Charity funding correlates negatively with societal output, probably because their main selection criterion is scientific quality. Perhaps charities perceive the creation of new knowledge about a specific disease as socially relevant in itself. Also, they might have decided to disseminate this new knowledge to society at large themselves rather than leave this to the research group. For funding from industry and ministries, no relationship was found. It is likely that the research commissioned by these stakeholders already has a societal or economic goal. Therefore, funding received from industry and ministries can be considered as an indicator for societal output.

Stimulating socially relevant activities cannot solely depend on incentives in the funding system. Appreciation for socially relevant activities of a researcher should also be granted by the organisation itself and by the scientific community. It will certainly take some time before the associated cultural change will take effect. But in the end, the use of broader indicators that assess the research process does more justice to the variety of duties and responsibilities of research groups than narrower indicators that focus on research outcomes.

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