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Aiming for impact: Differential effect of motivational drivers on effort and performance in knowledge valorisation

Linda H. M. van de Burgwal [1,2,*], Rana Hendrikse[1] and Eric Claassen[1,2]

[1]Athena Institute, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands and [2]Sovalacc BV, Rotterdam, The Netherlands

*Corresponding author. E-mail: lvdburgwal@gmail.com

Abstract

Societal engagement of scientists critically depends on their intrinsic motivation. Nevertheless, it remains unclear how motivational drivers influence effort and performance in engaging with four distinct stakeholder domains: academic, civil society, state-governmental, and economic. This article tests motivational drivers in a survey among 706 Dutch Life Scientists to study direct and indirect effects on effort and performance and finds that drivers differentially influence effort and performance in the four domains. Analysis supported the identification of a fourth category of drivers: 'moral'—next to the well-recognised gold, ribbon, and puzzle drivers—and demonstrated their importance for performance in the civil society and state-governmental domains, two domains that have been underserved in previous studies. Pecuniary drivers influenced engagement with academic, as well as economic domains. In line with these findings, spreading responsibilities for engagement with different domains in line with the interests and motivations of individual scientists is recommended.

Key words: knowledge valorisation; knowledge transfer; motivation; third mission; university external engagement; societal impact

1. Introduction

Effective knowledge valorisation can lead to a range of societally relevant outcomes, including the development of new products and services, contributions to complex challenges, and improving global competitiveness (Baycan and Stough 2013; Rasmussen and Rice 2011). Knowledge valorisation is understood as the creation of societal value from knowledge by translating research findings into innovative products, services, processes, and/or business activities (Benneworth and Jongbloed 2010; De Jong 2015; Hladchenko 2016) through 'knowledge-related collaborations by academic researchers with non-academic organizations' (Perkmann et al. 2013). As such it consists of different informal and formal channels that reinforce each other (Jacobsson and Perez Vico 2010).

Societal impact is seldom the result of arm's length transfer of scientific outcomes, and the success of university knowledge valorisation policies is, among other factors, strongly dependent on the commitment of individual actors to knowledge valorisation (Davis et al., 2011; Derrick and Bryant 2013). Incentives such as revenue sharing, equity sharing and attributing prizes and bonuses are important but can only go so far in engaging academics (van de Burgwal et al. 2017). Next to the availability of time, the presence of clear policies and the presence of monetary and non-monetary rewards, commitment of academic researchers in knowledge valorisation is primarily influenced by individual motivation of scientists (D'Este and Perkmann 2011; De Jong et al. 2016; Harvey et al. 2015; Radas and Vehovec 2006).While most European countries have adopted policies and implemented programmes to address institutional barriers hampering knowledge valorisation (Geuna and Muscio 2009; Kochenkova et al. 2016), the engagement of scientists with valorisation processes and relevant stakeholders remains a factor that deserves specific attention.

Within the context of knowledge valorisation, many studies used the theory of planned behaviour to investigate motivational drivers. Such studies focused on which drivers influenced the intention of researchers to perform certain behaviour (Dermentzi et al. 2016; Guerrero and Urbano 2013; Hayter 2015; Miranda et al. 2017) or studied the differential effect of motivational drivers and external factors on intention (Goethner et al. 2012). Based on these studies, it is now generally accepted that motivational factors differentially affect specific forms of societal engagement (Beyhan and Rickne 2015;

D'Este and Perkmann 2011). However, research efforts have been skewed to interactions of a commercial nature, such as research commercialisation, academic entrepreneurship, patenting, and technology transfer, while neglecting interactions with state-governmental, economic, and lay publics (Baldini 2011; Lam 2011; Muscio et al. 2016). It, therefore, remains unclear how this link between motivational drivers and behaviour looks like for a broad conceptualisation of knowledge valorisation that goes beyond conventional university–industry interaction and research commercialisation. Only recently have scholars considered how motivational drivers differentially impact the intention of academics to engage in broader academic engagement activities, including via interactions with public administrations, non-profit organisations, and the general public (Benneworth and Jongbloed 2010; D'Este and Perkmann 2011; Dijkstra et al. 2015; Iorio et al. 2017; Olmos-Penuela et al. 2015; Ramos-Vielba et al. 2015). These studies, however, investigated motivational drivers in isolation, providing in-depth insight into motivational drivers for individual engagement activities, but failing to deliver insight into the differential influence of motivational drivers on specific forms of engagement.

Furthermore, although these studies imply that increased effort is linked to improved outcomes, this relationship is not elucidated further. Whereas the meditating effect of academic engagement on the relation between motivation and performance within the context of knowledge valorisation was hypothesised in an analytical framework on external engagement by researchers (Perkmann et al. 2013), this relationship has not been studied yet.

When zooming in on behaviour, short-term effort can be divided into three different sub concepts (Bonner and Sprinkle 2002): direction (the task an individual engages in), duration (the length of time an individual engages in this activity), and intensity (the amount of attention an individual devotes to a certain activity). Consequently, effort direction and duration can be measured directly and are operationalised as the time committed to a certain behaviour (Brown and Leigh 1996; Goodman et al. 2011). Effort intensity or quality, however, is a separate concept and reflected primarily in the outcomes of behaviour. Thus, although increased effort duration may improve the performance of individuals, this is not necessarily the case (Bonner and Sprinkle 2002; Goethner et al. 2012). From an opposing perspective, motivation in itself may lead to higher performance by positively influencing the effort intensity while keeping the effort direction and duration constant. Effort can thus be seen as a partially mediating factor, describing a pathway through which motivation leads to a certain performance (via effort direction and duration) while also enabling a direct effect of motivation on performance (via effort intensity) (Baron and Kenny 1986).

In-depth studies on this relationship, however, have been scarce. Studies that looked into academic engagement primarily investigated how factors such as linkages with knowledge users (Landry et al. 2006), gender (Göktepe-Hultén 2010), age (Boardman and Ponomariov 2009) and seniority (D'Este and Perkmann 2011) influenced performance. A more recent study linked motivation with behaviour by investigating the relation between motivational drivers and the variety and frequency of interactions with external stakeholders (Iorio et al. 2017). Many studies took a retrospective perspective to investigate which motivations contributed to certain behaviour (Baldini et al. 2007; Fini et al. 2009; Rizzo 2015), but did not study the performance measurements based upon this motivation. Consequently, the relationship between motivation, effort, and outcomes in the field of knowledge valorisation is still poorly understood. From an academic point of view, this focus hampers a broad understanding of how motivational factors contribute to engagement and performance in knowledge valorisation. Moreover, the skewed perspective on interactions with the economic domain might lead academics and policy makers to wrongly assume that only commercial activities constitute knowledge valorisation and as such limit rather than expand the societal impact of science (De Jong et al. 2016).

This article addresses this knowledge gap by combining the two research streams on motivation and performance in the field of knowledge valorisation. It builds upon an existing theoretical model of the mediating effect of effort on the relation between motivational drivers and performance (Goodman et al. 2011; Perkmann et al. 2013). Relying on an in-depth, cross-sectional survey among 706 Life Scientists in the Netherlands this relationship is explored for academic engagement and performance in a broad conceptualisation of knowledge valorisation. Based on a path analysis, we find support for the distinction between personal and moral drivers as two separate intrinsic motivators for delivering value to the general public and public policy. Our results furthermore indicate that efforts made in the societal domains are perceived as reinforcing and find that pecuniary drivers are relevant for output in the academic domain.

2. Conceptual framework

2.1 Societal output in a broad conceptualisation of knowledge valorisation

To operationalise performance, the study builds upon a framework that extends the concept of knowledge valorisation beyond research commercialisation and university–industry interaction. The societal quality indicator matrix distinguishes four types of communities with whom academics can engage and different corresponding impacts: engagement with the academic community leading to an impact on knowledge, with the general public leading to an impact on culture, with industrial stakeholders leading to an impact on welfare and finally with government agencies and professional communities leading to an impact on well-being (Hakala and Ylijoki 2001; Lam 2011; Mostert et al. 2010; van Ark and Klasen 2007).

2.1.1 Engagement with the academic community: impact on knowledge

Activities within the knowledge domain can in turn be conceptualised in four dimensions. The traditional dimension includes two of the most often used indicators: the number of scientific publications and the number of highly cited publications (Budd 2017; De Silva and Vance 2017). Although these indicators are disputed because they may capture and lead to unwanted side effects, the general consensus is that these metrics are the best tools available to capture the quality and influence of academic output (De Silva and Vance 2017; van Dalen and Henkens 2012). Individual indicators relate to recognition by academic peers such as invitations to present on scientific conferences and being awarded with scientific prizes and rewards (Nelson 2012). Two indicators that hint towards the industrial relevance of research findings but mostly capture the broadness of academic output are the number of publications in collaboration with the non-scientific sector and the non-scientific citations of academic work, for example, in patents. Finally, a tacit form of impact is related to capacity building, which has been operationalised as the supervision of PhD candidates and the provision of courses for academic colleagues (Oortwijn et al. 2008; van Ark and Klasen 2007).

2.1.2 Engagement with civil society: impact on culture

Impact in the civil society or cultural domain refers to increased public understanding of scientific progress, which is mainly achieved by contributions via the (mass) media (Peters 2013). Most prominently, this entails contributions to the popular media, such as television programmes or newspapers (Nelson 2012). Academics also contribute to public understanding by developing lay man's publications or text books for secondary education (Loikkanen et al. 2009), whereas a more informal approach includes active contributions to Internet publications such as public websites or news forums (Ranger and Bultitude 2016). Altmetrics represent an approach to measure the public engagement with research by looking at how often (open access) articles are viewed or commented upon (Bornmann 2014). Finally, in the cultural domain the expertise of scientists can also be recognised and unlocked via memberships of public organisations (Mostert et al. 2010).

2.1.3 Engagement with the economic domain: impact on welfare

The domain that is most elaborated upon, next to the academic domain, is the economic domain. A prominent indicator in this field is the number of patent applications, which for the individual researcher translates to being mentioned as inventor on a patent application (van Dongen et al. 2014). While patents merely capture the invention, the resulting innovative activity is captured by contributions to (improved) products and services (Flipse et al. 2014; Makkonen and Inkinen 2014) which may also result from consultancy activities to companies (Link et al. 2007; Wright et al. 2008). These activities are primarily preceded by researchers having a relevant professional network with companies (Langford et al. 2006; Lenihan 2011; Tijssen 2006) and may lead to job creation for others (Lenihan 2011; Makkonen and Inkinen 2014).

2.1.4 Engagement with the state-governmental and professional domain: impact on well-being

Within the well-being domain, impact is generated through interactions with state-governmental stakeholders or professionals in the research field. Knowledge exchange can take the form of publications in professional journals (Mostert et al. 2010) or performances in committees (Hall and Page 2015). Whether the knowledge is used in practice directly (Debackere and Veugelers 2005; van Ark and Klasen 2007) or indirectly by developing new guidelines or standards (Mostert et al. 2010; Oortwijn et al. 2008), the ultimate goal of these types of activities is to contribute to the quality of life (Hicks, 2005).

2.2 Motivational drivers in the context of knowledge valorisation

To identify different motivational drivers that have been discussed in the context of academia, a systematic literature review was conducted (see Supplementary Material 1 for search syntax, Supplementary Material 2 for the selection process and Supplementary Material 3 for an overview of the included articles). The systematic literature review identified twenty-five distinct motivational drivers that were discussed in the context of academia (Table 1). Building on the accepted categorisation of gold, ribbon, and puzzle (Lam 2011), the drivers were clustered to pecuniary, career, and personal categories, respectively, and to a fourth, emerging category of moral motivation.

2.2.1 Gold or pecuniary motivations

Gold is the most straightforward extrinsic motivator and refers to pecuniary benefits for academics, either as a result of performance in the ribbon domain via salary increases (Stephan 1996), but more recently also via pecuniary benefits of broader engagement, via shares in spin-off companies, revenues from licenses, bonuses, and prizes (van de Burgwal et al. 2017). Although in general, pecuniary motives are described as non-relevant for academics, they are described as relevant for those academics that are active in industry cooperation (Lam 2011). The effect of pecuniary incentives on performance has been debated in many studies on motivation (Sachau 2007) but it seems that economic considerations may influence job choice considerations especially for more renowned researchers (Janger and Nowotny 2016).

2.2.2 Ribbon or career motivations

Ribbon is another extrinsic motivator and refers to researchers valuing the outcomes of recognition and access to research that follows professional performance (Lam 2011). Although professional performance is primarily signalled by academic publications and citations (Ankrah et al. 2013; Franco and Haase 2015), researchers are increasingly assessed upon their societal engagement, especially in the economic domain (Arzensek and Kosmrlj 2014; Dermentzi et al. 2016; Rizzo 2015). Other motives in this category relate to gaining increased attention in their field of research (Dermentzi et al. 2016; Owen-Smith 2003), building their reputation (Göktepe-Hultén 2010; Rizzo 2015) and ultimately securing their own employment (Ankrah et al. 2013; Franco and Haase 2015). In turn, this can increase professional performance by signalling the expertise of the researcher to potential research partners (Freitas and Nuvolari 2012) and subsequently contribute to researchers attracting financial, material, and/or immaterial resources for their research (Baldini 2011; Beyhan and Rickne 2015; Closs et al. 2013; Fini et al. 2009; Franco and Haase 2015; Hayter 2011; Olmos-Penuela et al. 2015; Radas and Vehovec 2006). Indeed, some researchers were found to seize knowledge valorisation opportunities to further contribute to the extended research capacity (Rizzo 2015). Another dimension of career motives relates to securing resources for research colleagues (Beyhan and Rickne 2015) and employment opportunities for colleagues (Iorio et al. 2017; Rizzo 2015) and students (Ankrah et al. 2013; Closs et al. 2013), since these increase the capacity of academics to conduct valuable research.

2.2.3 Puzzle or personal motivations

Puzzle refers to the intrinsic motivation by academics to engage in challenging and creative activities and has been long recognised as a driving factor for researchers (Cotgrove 1970; Eiduson 1962; Gustin 1973). Intrinsic motivation refers to doing something because it is considered desirable in itself and for scientists this is mostly referenced as the joy that researchers experience when addressing challenging puzzles (Closs et al. 2013; Levin and Stephan 1991). This includes intrinsic satisfaction derived from pioneering in new fields (Closs et al. 2013; Miranda et al. 2017; Rizzo 2015) and advancing the quantity and relevance of their scientific output (Ballabeni et al. 2014; Hayter 2011). Within the era of knowledge valorisation, it is increasingly being recognised that researchers may also experience joy when they engage with societal stakeholders and share scientific knowledge with a wider public (Dijkstra et al. 2015; Lam 2011; Miranda et al. 2017; Uctu and Jafta 2012). Other personal drivers relate to being subject to more constant changes (Miranda et al. 2017); working on real

Table 1. The systematic literature review identified 25 distinct motivational drivers that were discussed in the context of academia

Motivation	Driver	Explanation	Studies*
Career	Prestige	Academic reputation and status, recognition, visibility, attention for research	1, 3, 4, 5, 8, 19, 13, 14, 15, 16, 23, 25
	Career success	Publications, stimuli for new research, professional development, good for Curriculum Vitae	1, 3, 4, 7, 8, 9, 13, 15, 17, 18, 20, 22
	Institutional benefit	Enhance university's reputation, ensure cutting edge research, fit universities' mission	1, 2, 20
	Networking	Build and expand personal or professional network	2, 9, 12, 14, 19, 21
	Affective duty	Grants or jobs for colleagues and students; motivate and teach students and faculty better	1, 3, 4, 7, 10, 13, 14, 17, 19, 20, 21, 22, 23
	Financial resources	Generate research funds, grants, angel investments, or venture capital for research. Become independent from government funding to secure the continuity of the research	1, 3, 4, 7, 8, 10, 12, 13, 14, 15, 17, 19, 20, 21
	Tangible resources	Generate resources such as equipment, materials, and facilities for research	1, 3, 4, 7, 10, 1214, 19, 20, 21, 22
	Intangible resources	Access to expertise, tacit knowledge, training, and information to benefit research	1, 2, 12, 21
	Peer pressure	Being motivated or pressured by university/colleagues/society	1, 2, 17, 18, 23
Personal	Challenge	Intellectual challenge, solving problems in knowledge/industry (puzzles)	2, 5, 10, 12, 13, 22, 23
	Curiosity	Explore new lines of research, learn about business, satisfy intellectual curiosity	1, 5, 6, 7, 11, 12, 17, 19, 21, 25
	Joy	Personal satisfaction, pride, enjoyment, fun	2, 10, 13, 17
	Application of research	Test feasibility and practical application of research, reduce barriers for technology take-up	1, 7, 11, 12, 14, 15, 17, 19, 20, 21, 23, 24, 25
	Autonomy	Be independent	9, 17, 25
	Job creation	Create job for self, which fits the academic competences	23
	Seizing an opportunity	Seeing a business opportunity or societal need and wanting to fulfil that need	23, 25
Moral	Duty—knowledge	Promoting and advancing innovation, technology, science, and knowledge	1, 5, 13
	Duty—society	Enriching the general public, contributing to political debate	1, 2, 6, 10, 13, 17, 21, 25
	Duty—welfare	Contributing to the wealth of the country	1, 10, 14, 21
	Duty—well-being	Contributing to health and well-being; researching and curing diseases; developing treatments, guidelines, protocols	5, 11, 13, 21, 23
Pecuniary	Intellectual property	Personal income from patents or other intellectual property	1, 3, 4, 5, 7, 8, 12, 16, 18, 19, 21, 23, 24
	Consultancy	Personal income from consulting or training	23
	Research collaboration	Personal income from research collaboration or contract research	12, 22
	Spin-offs or launched products	Personal income coming from spin-offs or products	8, 10, 14, 17, 19, 23, 25

*See Supplementary Material 3 for reference data on the included studies.

problems encountered by organisations (Arzensek and Kosmrlj 2014); and learning from new contexts and becoming more autonomous (Miranda et al. 2017; Uctu and Jafta 2012).

2.2.4 Sun or moral motivations

Whereas the personal motivators described earlier refer to a hedonistic type of intrinsic motivation, another type of intrinsic motivation can be distinguished that is of a more normative nature. This type of intrinsic motivation relates to acting appropriately without having regard for potential beneficial outcomes (Lindenberg 2001), and has only recently been included in studies on knowledge valorisation. By engaging with society, many researchers feel that they contribute to the application of their research to practice (Ankrah et al. 2013; Closs et al. 2013; Iorio et al. 2017), which may lead to contributions to the public debate (Ankrah et al. 2013; Besley 2015) and improving products on the market (Closs et al. 2013; Miranda et al. 2017). Although for some the mere transfer of knowledge of technology is a driver in itself (Hayter 2011; Iorio et al. 2017), the actual application of their knowledge is considered an important aspect of this motivation (Rosa and Dawson 2006; Uctu and Jafta 2012). In this sense, academics are also described to be driven by wider societal benefits, including improving the quality of life (Dijkstra et al. 2015; Olmos-Penuela et al. 2015) and contributing to the welfare of the local context or country (Baldini et al. 2007; Fini et al. 2009; Iorio et al. 2017), which is why we propose to categorise this type of motivations as 'sun', referring to its non-exclusive nature.

3. Methodology

This study aims to provide a first understanding of the relationship between motivational drivers, effort and societal impact on four dimensions of knowledge valorisation. The study, therefore, makes use of a survey design in a cross-sectional manner.

3.1 Study sample and data

To investigate the effect of motivation on scientists' effort and performance in knowledge valorisation, this study used a cross-sectional survey among life scientists in the Netherlands.

3.1.1 Study context

The Netherlands is one of Europe's leading countries in knowledge valorisation (Dicke et al. 2016; Hladchenko 2016) and knowledge

valorisation has been incorporated in state policy since 2004 (De Jong 2015). Directed by governmental policy, the universities in the Netherlands have all adopted strategic agendas that describe their approach to knowledge valorisation, which includes economic and societal aspects (Hladchenko 2016). All universities within the Netherlands have access to state funding designated for knowledge valorisation activities (Hladchenko 2016).

As part of its valorisation policy, in 2010, the Dutch government appointed nine key sectors which were considered crucial for the Dutch knowledge economy and these sectors have been highlighted in innovation support policies and the life sciences was one of them (Hladchenko 2016). The life sciences domain refers to all sciences that study living organisms or that research the technologies used to study these organisms. Based upon its close relationship with industry and societal problems such as obesity and the ageing population, it is a field of research that is relevant for all four domains of knowledge valorisation (Benneworth and Jongbloed 2010; Dicke et al. 2016). In addition, it is historically one of the most developed sectors of knowledge valorisation (Vallas and Kleinman 2008).

3.1.2 Reconnaissance of field

Before the start of this study, interviews with thirty-eight Dutch respondents in the domains of science, business, and policy were conducted. These interviews contained rich information about motivational drivers of Dutch scientists to engage in knowledge valorisation and were used to provide insight into whether the motivational drivers of Dutch scientists qualitatively differed from those described in literature. Since no differences between the interviews and the literature were found, these interviews were used to provide in-depth insight into the workings of motivational drivers in the community of practice.

3.1.3 Study sample

The starting point for this study was the websites of the thirteen universities and eight university medical centres in the Netherlands. Based on the aforementioned definition of life sciences, it was determined which research groups in which faculties focused on the life sciences. This included fields of biology, medicine, health sciences, and technological life sciences. Since literature describes many differences between early stage and late stage researchers (Janger and Nowotny 2016), we only included professors and principal investigators associated to those research groups. Selection criteria did not include an assessment of whether researcher had had any prior involvement with knowledge valorisation. 2,733 e-mail addresses were collected based on information on the universities' websites, Google searches, via Narcis (a Dutch database for scientific information) and by scanning publications for contact details.

After receiving an initial invitation, all scientists received two general reminders and one final reminder to increase response rates (Cook et al. 2000). The first invitation was sent out in August 2016 and the survey was closed in October 2016. At that moment, 915 responses had been collected, indicating a response rate of 33.5%, which is well within the norm for surveys (36 ± 13%) (Baruch and Holtom 2008). All data were treated confidentially and were processed anonymously.

Data analysis was carried out using the statistical software package IBM SPSS 20. All respondents who were not a professor or principal investigator were excluded, as well as scientists who were no longer performing research or indicated they were not active in the life sciences. After data cleaning, 706 responses were left, indicating a completion rate of 77%, which is relatively high for web-based surveys (Cook et al. 2000). The characteristics of the remaining sample are shown in Table 2.

Table 2. Sample characteristics

Variable		Mean (SD)	No. of valid responses
Scale research		6.2 (2.3)	701
Years since First Publication		24 (8.7)	702
Variable	**Category**	**Percentage**	**No. of valid responses**
Gender	Female	27.4	701
	Male	72.6	
Age	30–39	9.8	705
	40–49	28.2	
	50–59	43.1	
	60–69	17.9	
	>70	1.0	
Professor	Yes	43.9	706
	No, PI	56.1	

3.1.4 Survey design

The cross-sectional survey was developed in SurveyMonkey and started with an informed consent, a notice of confidentiality and a time indication. A pilot study with seven respondents was conducted to ensure that all questions were clear and to verify how much time on average it would take to fill out the questionnaire.

During the survey, respondents were asked to indicate to what extent specific motivational drivers applied to them (see Supplementary Material 4 for an overview of these drivers) on five-point Likert scales.

The same approach was used to identify how well they performed on selected performance indicators for each of the four domains of societal impact highlighted in the societal quality indicator matrix (see Supplementary Material 5 for an overview of these indicators). The questions in the survey did not distinguish between the four stages of impact (i.e. knowledge production, knowledge exchange, knowledge use, and earning capacity), since this study aimed to look at the outcomes of behaviour rather than at the process through which impact was achieved. Although the self-reporting of performance has certain drawbacks in terms of potential biases in self-reported performance, this approach was taken since it enables full anonymisation of the respondents. Moreover, it circumvents many of the drawbacks encountered with metrics and indicators for societal impact of knowledge, especially the lack of appreciation of the value and quality of interactions with stakeholders and the neglect of a wider interpretation of knowledge valorisation (Grimaldi et al. 2011; Martin 2011). To reduce reporter bias, for the knowledge and economy domains control questions on standardised and accepted performance measures which did not require respondents to conduct additional research were added to link with self-reported performance. These questions included the H-index, the number of patents on which respondents were listed as an inventor, whether respondents collaborated with industry, and whether respondents had started a spin-off company.

The questions within each subject (i.e. motivation and performance domain) were randomised.

Effort was operationalised as the percentage of time academics spent on activities within each of the four domains and a 0–100% scale was used for questions regarding effort on each of the domains (Brown and Leigh 1996; Goodman et al. 2011).

3.1.5 Control variables

To improve the predictive value of our explorative Model 5 control variables that were previously described to influence effort and/or performance in the field of knowledge valorisation were included. Scientists engaged in basic research might be less motivated to engage in commercialisation or might be less able to reach a high performance due to the embryonic nature of their knowledge (Davis et al. 2011; Goethner et al. 2012), hence we asked respondents to indicate how basic or applied their research was on a scale from 1 to 10. Gender was included to control for the differences in likeliness of industrial engagement (Boardman and Ponomariov 2009; Göktepe-Hultén 2010; Link et al. 2007). Seniority is described as an influence on engagement as well. To distinguish between seniority in the form of job security (Perkmann and Walsh 2007; Stuart and Ding 2006) and seniority resulting in social capital accumulated over the years (Giuliani et al. 2010) we controlled for both variables by asking for professorial status and the year of the first published article. A final control variable included the entrepreneurial orientation of scientists to enable us to capture whether effects were dependent on the value orientation of the academics (Lam 2011).

Importantly, these control variables are all at the individual level and do not reflect the team or organisational level in which the scientists operate. Although research is conducted in groups and university prestige are important to improve access to resources, the value of individual networks is even more important (Arzensek and Kosmrlj 2014; Dermentzi et al. 2016; Olmos-Penuela et al. 2015). Moreover, considering the relatively homogenous research setting of the life sciences within the Netherlands, differences in support infrastructure, such as the existence of industry and venture capital, are negligible. This study is therefore of an explorative nature that aims to identify how individual-level differences can influence motivation, effort, and performance (Grimaldi et al. 2011).

The complete analytical model used for this study is shown in Figure 1.

3.2 Data analysis

3.2.1 Confirmatory principal component analysis

A confirmatory principal component analysis (PCA) was conducted on the thirty-three motivational items with oblique rotation (oblimin). The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis (KMO = 0.88) and all KMO values for individual items were >0.80, well above the acceptable limit of 0.5 (Field 2009). Bartlett's test of sphericity χ^2 (528) = 6,340, $P < 0.0001$, indicated that correlations between items were sufficiently large for PCA.

An initial analysis was run to obtain eigenvalues for each component in the data. Seven components had eigenvalues over Kaiser's criterion of 1 and in combination explained 53.4% of the variance. The scree plot was slightly ambiguous and showed inflexions that would justify retaining both Components 3 and 4. Given the large sample size, the convergence of the scree plot and Kaiser's criterion on four components, this is the number of components that were retained in the final analysis. The reliability of the scale was tested using Cronbach's alpha (Cronbach & Meehl 1955; Tavakol and Dennick 2011).

Average scores for performance were calculated by averaging the Likert scores (Matell and Jacoby 1971) for performance within specific domains. Internal validity of the questionnaire was also tested using Cronbach's alpha.

3.2.2 Mean results of motivation and performance

Based upon this categorisation, the mean results of motivation and performance were explored. Since the results were non-normally distributed, a Friedman's ANOVA was conducted to test the differences between the motivational and performance categories with *post hoc* Wilcoxon signed-rank tests. The correlation between H-index and performance in the knowledge domain as well as the correlation between patent count and performance in the economy domain was tested with bivariate Pearson's rho correlations. Mann–Whitney tests were conducted to analyse the differences in motivation and performance between professors and non-professors. The significance value was set at 0.05 and a Bonferroni correction was applied for *post hoc* tests.

3.2.3 Current effort, desired effort and entrepreneurial orientation

Wilcoxon signed-rank tests were conducted to analyse the differences between current and desired effort on the different domains and a Kruskal–Wallis test was performed to check whether the current and desired effort per domain was dependent on entrepreneurial orientation. In addition, a Jonckheere–Terpstra test was conducted to see whether a trend was visible depending on whether respondents were more or less entrepreneurial.

3.2.4 Mediation analysis

After the data were explored by analysing descriptive statistics and bivariate Pearson rho correlations (see Supplementary Material 6), a mediation model was tested for the mediating role of effort on the relation between motivation and performance as this allowed us to examine the relationship in a more comprehensive manner than via multiple regressions. In this mediation analysis, the relationship

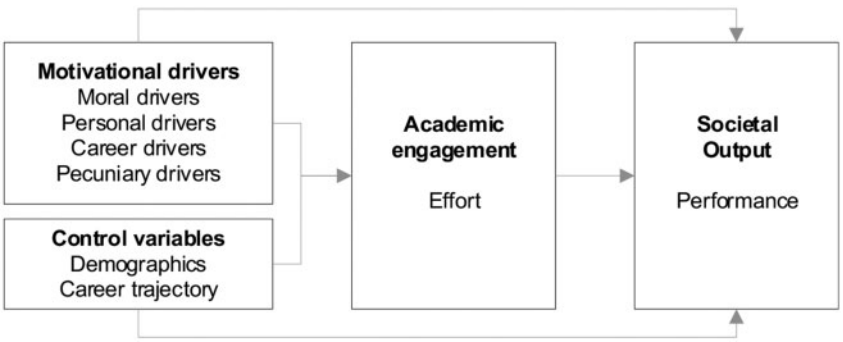

Figure 1. Analytical model of the mediating relationship between motivational drivers, effort, and performance.

between outcome in a certain domain, effort in a certain domain and the four motivational categories was tested via multiple linear regressions, using the PROCESS Procedure for SPSS (Hayes 2013). The scale of the research (fundamental vs. applied on a scale from 1 to 10), the years of experience of the respondent, their gender (0 = female, 1 = male), their entrepreneurial orientation (1 = traditional to 4 = entrepreneurial), and their professorial status (1 = professor) were included in the analysis as control variables. The significance of indirect effects was tested via percentile bootstrap confidence intervals, using 10.000 bootstrap samples. The model coefficients for this analysis are shown in Supplementary Material 7.

4. Results

4.1 Confirmatory principle component analysis

Table 3 depicts the structure matrix for the factor loadings after rotation and shows there are four distinct components of motivation, each with an internal consistency (Cronbach's alpha) well above the 0.6 cut-off value. The items that cluster on the same components confirm that Component 1 represents career motives, Component 2 represents personal motives, Component 3 moral motives, and Component 4 pecuniary motives. The Cronbach's alpha for these categories were all between 0.74 and 0.82, indicating a good reliability among the indicators of each construct (Kline 2013).

Table 3. The structure matrix from the PCA shows there are four components of motivation, each with an internal consistency (Cronbach's alpha) well above the 0.6 cut-off value

	Component			
	1	2	3	4
Employment colleagues	0.71			
Resources colleagues	0.68			
Financial resources research	0.65			
Employment students	0.64			
Reputation	0.57			
Network	0.55		−0.40	
Material resources research	0.51			0.42
Opportunity	0.51			
Immaterial resources research	0.50			
Attention	0.48	0.41		
University prestige	0.46			
Expectations colleagues	0.46			
Employment self	0.42			
New ideas		0.69		
Advance science		0.68		
Curiosity		0.61		
Pioneer		0.61		
Joy		0.57		
Sharing knowledge science		0.53		
Challenge		0.52		
Autonomy		0.48		
Apply to practice			−0.81	
See application			−0.81	
Improve products			−0.74	
Quality of life society			−0.74	
Public debate			−0.55	
Country welfare			−0.48	
Knowledge transfer			−0.47	
Bonuses				0.78
Commercial				0.78
Shares				0.76
Prizes				0.62
Income colleagues				0.56
Eigenvalues	*7.17*	*2.61*	*2.54*	*1.59*
% of variance	*21.7*	*7.9*	*7.7*	*4.8*
Cronbach's alpha	*0.82*	*0.74*	*0.80*	*0.76*

4.2 Mean results of motivation and performance

As shown in Figure 2, there were statistically significant differences in the scores between all four motivational categories and all four performance categories.

4.2.1 Motivation

The omnibus test showed that motivation of the participants significantly differed between the four different categories [$\chi^2(3) = 1{,}687$, $P < 0.0001$], and the *post hoc* Wilcoxon signed-rank tests demonstrated that this was true for differences between all four categories at the $P < 0.0001$ level (Figure 2). In line with expectations, on average academics were most motivated by personal drivers, followed by moral and career drivers. Pecuniary drivers were least important for academics. The largest difference was found between personal (Mdn = 4.33) and pecuniary (Mdn = 1.40) motivation ($T = 784$, $P < 0.001$, $r = -0.61$), whereas career and moral had the smallest differences (Mdn = 3.25 and Mdn = 3.43, respectively, $T = 75{,}326$, $P < 0.001$, $r = -0.21$). Although there was no statistically significant difference between professors and non-professors in their career, personal, or pecuniary motivation, there was a statistically significant but small difference in moral motivation between professors (Mdn = 3.57) and non-professor PIs (Mdn = 3.43), $U = 50{,}076$, $z = -2.79$, $P < 0.005$, $r = -0.11$.

4.2.2 Performance

To support the internal validity of the four distinct performance categories, Cronbach's alpha was calculated. All four performance indicators had a high internal validity, with Cronbach's alpha being 0.72 for the knowledge domain, 0.80 for the economy domain, 0.79 for the well-being domain and 0.78 for the culture domain. To test the external validity, the self-assessed performance measures were compared with four well-established and objectively measurable performance indicators, and statistically significant correlations were found. Performance on the knowledge domain had a statically significant correlation with the reported H-index ($r = 0.39$, $P < 0.01$) and performance on the economy domain statistically significantly correlated with the reported number of patents filed ($r = 0.38$, $P < 0.01$), with collaborations with the industry ($r = 0.36$, $P < 0.01$) and with spin-off creation ($r = 0.31$, $P < 0.01$).

Performance in each of the categories differed statistically significantly [$\chi^2(3) = 706$, $P < 0.0001$] (Figure 2B). These differences were significant between all categories at the $P < 0.0001$ level, with the performance being lowest for culture (Mdn = 2.25), highest for knowledge (Mdn = 3.33) and intermediate for welfare and well-being (Mdn is 2.71 and 3.00, respectively).

As expected, professors scored statistically significantly higher on all performance domains than non-professors, with medium effect sizes found for impact on knowledge (Mdn = 3.50 vs. Mdn = 3.17, $U = 34{,}576$, $z = -8.30$, $P < 0.001$, $r = -0.23$) and impact on well-being (Mdn = 3.20 vs. Mdn = 2.80, $U = 33{,}380$, $z = -8.13$, $P < 0.001$, $r = -0.22$) and small effect sizes found for impact on welfare (Mdn = 2.71 vs. Mdn = 2.71, $U = 46{,}611$, $z = -3.41$, $P < 0.001$, $r = -0.09$) and impact on culture

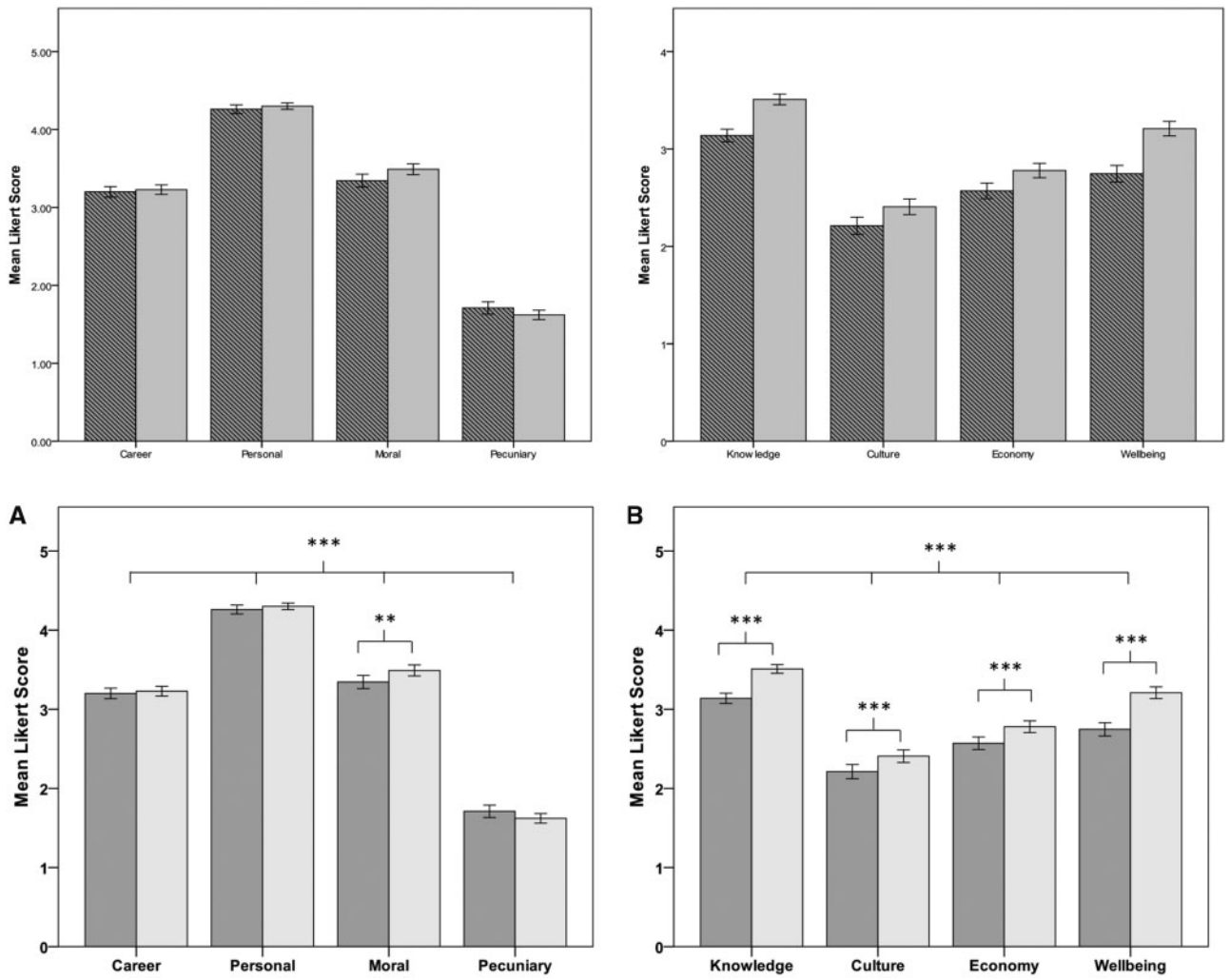

Figure 2. There were statistically significant differences between all four motivational categories **(A)** and all four performance categories **(B)**. As expected, professors (light grey bars) scored statistically significantly higher on all performance domains than non-professors (dark grey bars). There was no statistical difference between the motivations of both groups, except for moral motivation. Error bars: 95% confidence interval. **P < 0.005; ***P < 0.0001.

(Mdn = 2.25 vs. Mdn = 2.20, $U = 45{,}860$, $z = -2.89$, P < 0.01, $r = -0.08$).

4.3 Current effort, desired effort, and entrepreneurial orientation

The time spent on each of the different domains differed statistically significantly [$\chi^2(3) = 1{,}133$, P < 0.0001]. *Post hoc* tests demonstrated that significantly more time was spent on the knowledge domain (Mdn = 70) than on the culture (Mdn = 10, $T = 2{,}723$, P < 0.001, $r = -0.58$), welfare (Mdn = 0.00, $T = 411$, P < 0.001, $r = -0.61$), and well-being (Mdn = 10, $T = 3{,}579$, P < 0.001, $r = -0.58$) domains. Furthermore, the differences between welfare and well-being ($T = 13{,}088$, P < 0.001, $r = -0.38$) and welfare and culture ($T = 17{,}874$, P < 0.001, $r = -0.32$) were statistically significant with moderate effect sizes.

On average, respondents wanted to spend less time on knowledge ($T = 17{,}242$, P < 0.001, $r = -0.22$), and more time on culture ($T = 13{,}667$, P < 0.001, $r = -0.13$), welfare ($T = 6{,}919$, P < 0.001, $r = -0.13$), and well-being ($T = 13{,}225$, P < 0.001, $r = -0.17$) (Figure 3A).

Entrepreneurial orientation only influenced current and desired effort in the knowledge and economy domains, but not in the culture and well-being domains (Table 4). Jonckheere's test revealed a significant trend in the data: as the orientation was more entrepreneurial, less time was spent on the knowledge domain and more time was spent on the economy domain (Table 4). The same trend was observed for the time respondents wanted to spend on these domains. The current and desired efforts in the culture and well-being domains were not influenced by the entrepreneurial orientation.

Due to the large standard deviations and small to moderate effect sizes of these findings, a follow-up analysis based upon the desired direction of change was conducted. On average, respondents who wanted to reduce their time spent on welfare, wanted to increase their time spent on knowledge ($T = 702$, P < 0.001, $r = -0.27$) but did not want to change their time spent on well-being or culture (Figure 3B). This indicates that although time spent on the welfare domain was seen as conflicting with time spent on the knowledge domain, they did not see this time as conflicting with their efforts on the well-being and culture domains. Conversely, scientists who wanted to spend more time on welfare also wanted to increase their

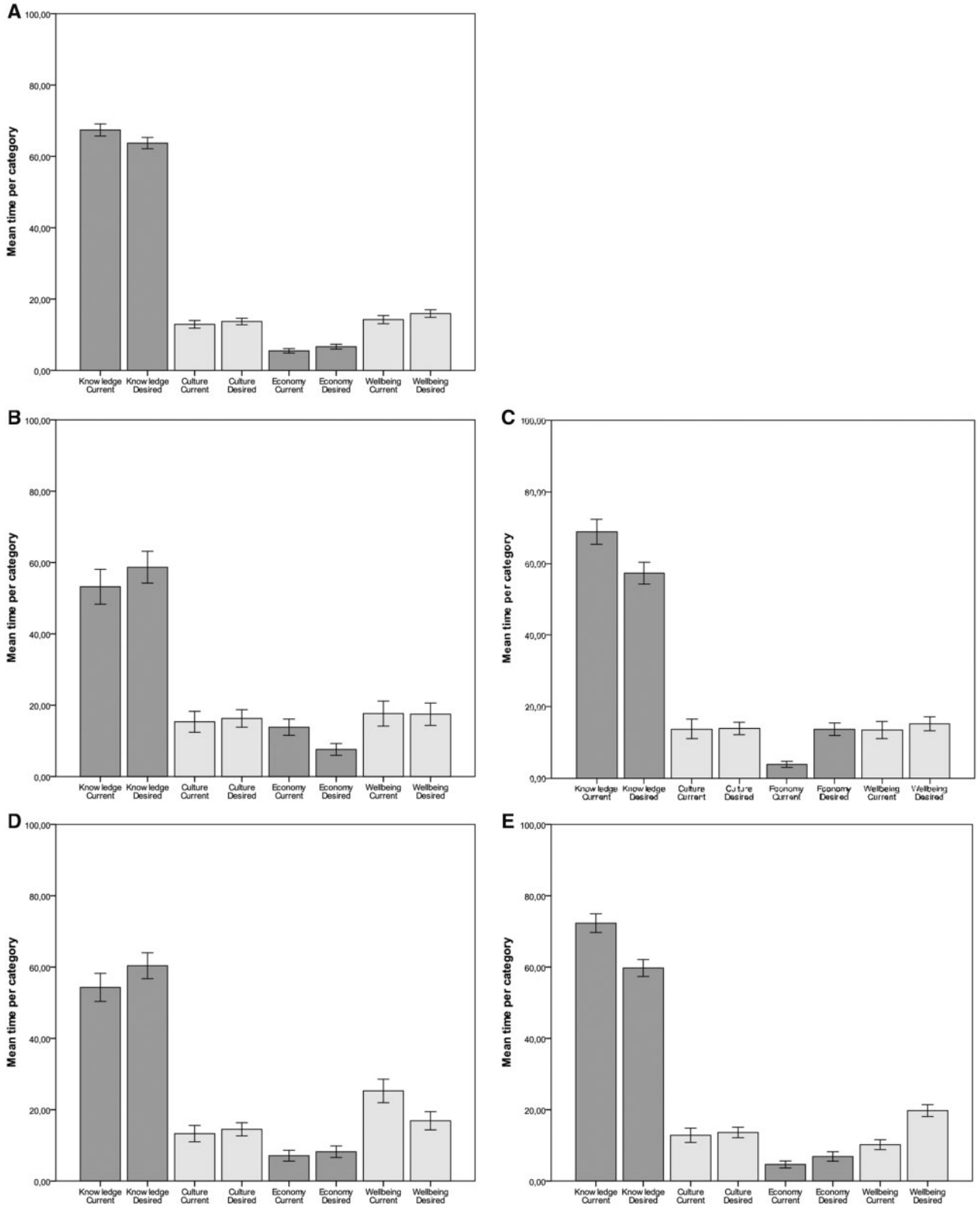

Figure 3. In general, scientists wanted to reduce their effort on the knowledge domain and increase their effort on the other domains **(A)**. While scientists who wanted to reduce their effort on the economy or well-being domain only wanted to compensate this by increasing their effort on the knowledge domain (**B** and **D**), scientists who wanted to increase their effort on the economy or well-being domain wanted to simultaneously increase their effort in one or both of the other non-academic domains (**C** and **E**). *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

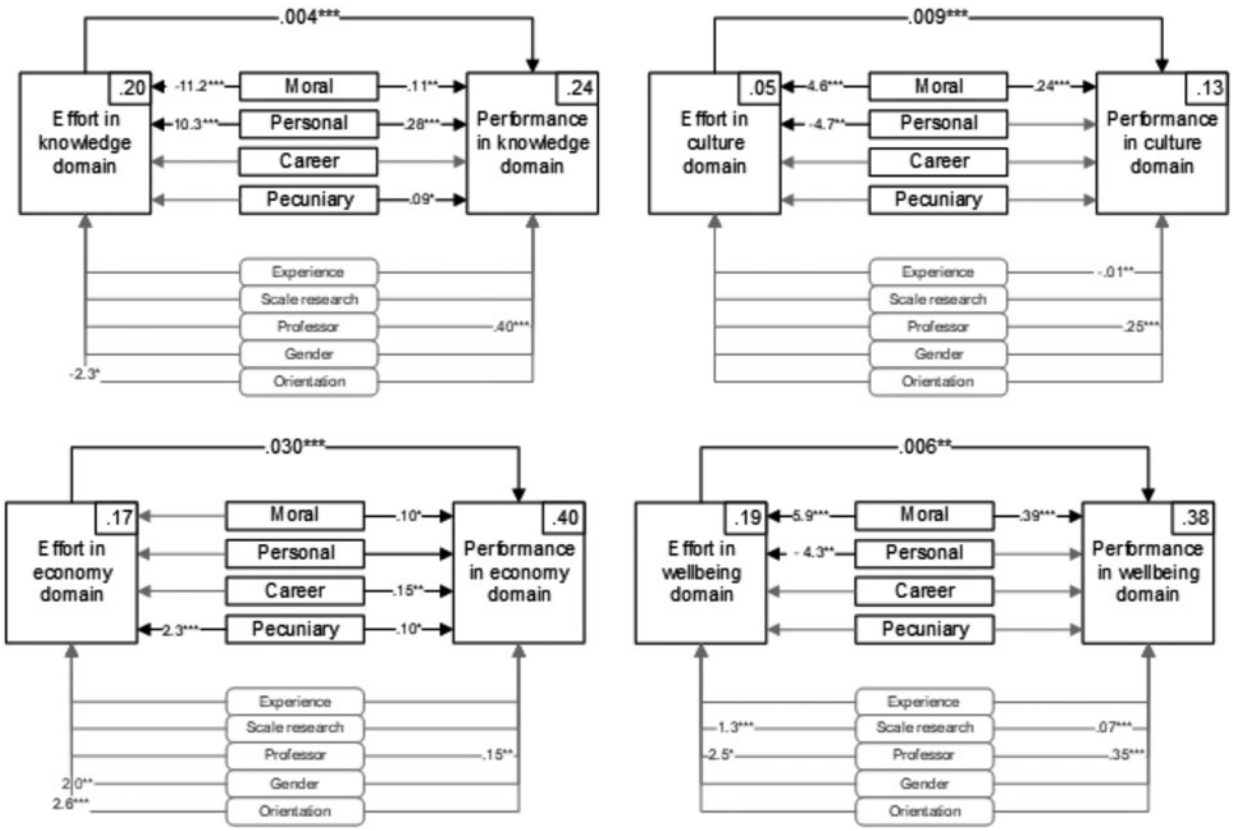

Figure 4. Results from the mediation analysis for performance in the knowledge, cultural, economy and well-being domain. Unstandardised effect sizes are shown.

Table 4. Entrepreneurial orientation only influenced current and desired effort in the knowledge and economy domains, but not in the culture and well-being domains

	Kruskal–Wallis test			Jonckheere–Terpstra Test			
	Chi-square	df	P	J	*z*	P	*r*
Knowledge current	23.2	3	<0.001	50,338	−4.45	<0.001	−0.18
Culture current	1.6	3	ns	62,507	0.902	ns	
Economy current	99.4	3	<0.001	80,864	9.56	<0.001	0.39
Well-being current	2.7	3	ns	61,854	0.612	ns	
Knowledge desired	24.8	3	<0.001	49,970	−4.45	<0.001	−0.18
Culture desired	1.0	3	ns	62,107	0.911	ns	
Economy desired	102.1	3	<0.001	81,615	9.92	<0.001	0.41
Well-being desired	0.8	3	ns	61,324	0.561	ns	

time spent on well-being ($T = 1{,}587$, $P < 0.02$, $r = -0.15$), indicating that they might even see a synergy between efforts in these two domains. Interestingly, such synergy with efforts made in the cultural domain was not indicated (Figure 3C). A similar trend was observed for scientists who wanted to spend less time on well-being. They also wanted to increase their time spent on knowledge ($T = 892$, $P < 0.001$, $r = -0.30$, Figure 3D) and not change their time spent on welfare or culture. From the opposing perspective, scientists who wanted to increase their time spent on well-being wanted to spend more time both on welfare ($T = 1{,}188$, $P < 0.001$, $r = -0.19$) and on culture ($T = 2{,}593$, $P = 0.004$, $r = -0.14$), indicating that they might experience a synergistic effect of efforts on all three domains (Figure 3E).

4.4 Mediation analysis

A simple mediation analysis using ordinary least squares path analysis provided insight into the direct effect of motivation on performance and the indirect effect of motivation through effort. The zero-order correlations for this analysis are presented in Supplementary Material 6. Variance inflation factors (VIF) were all between 1 and 2 and thus no evidence of multicollinearity was indicated (Hair et al. 2014).

Table 5. Effect decomposition: direct, indirect, and total effects of the distal predictors on academic performance

		Domain			
Variables		Knowledge	Culture	Economy	Well-being
Moral	Direct	0.11	0.24	0.10	0.39
	Indirect	−0.05	0.04		0.04
	Total		0.28	0.12	0.42
Personal	Direct	0.28			
	Indirect	0.04	−0.04		
	Total	0.32			
Career	Direct			0.15	
	Indirect				
	Total			0.15	
Pecuniary	Direct	0.09		0.10	
	Indirect			0.07	
	Total	0.09		0.17	

As can be seen in Figure 4 the effects of the four types of motivation on performance and effort differed per knowledge impact domain. As expected, for all domains effort significantly predicted performance, with a significantly larger effect size in the economy domain. Interestingly, moral motivation sorted direct and indirect effects in three of the four domains; only the economy domain saw solely direct effects. Whereas moral motivation positively affected performance and effort in the cultural and well-being domains, in the knowledge domain it had a negative relation with effort but not with performance. The total direct and indirect effect of moral motivation was not statistically significant (0.06, P = 0.11, Table 5). Personal motivation had a negative influence on effort in both cultural and well-being domains, but a strong positive influence on effort and performance in the knowledge domain. Additional to its expected relevance in the economy domain, pecuniary motivation also played in role in the knowledge domain where it had a direct effect on performance. Career motivation was not a predictor in any of the domains, neither for performance, nor for effort. Experience negatively affected the performance on culture and the scale of the research was only relevant for well-being. Gender only had a (negative) effect on the effort in the economy domain, but not on the performance. In contrast, being a professor had a positive relation on performance in all domains.

Summarising the findings from our mediation analysis, in Table 5 an overview of the direct, indirect, and total effect is shown for each of the motivational categories studied in this article. The total effect is calculated by summing the direct effect and the total indirect effect. Although moral motivation has a positive direct effect on performance in the knowledge domain, combined with the negative indirect effects via effort, the total effect is not statistically significant (0.06, P = 0.11).

5. Discussion and conclusion

5.1 Main findings

This study finds that motivational drivers differentially influence effort and performance in the four societal impact domains of knowledge, culture, economy, and well-being. Importantly, motivational drivers have both a direct and indirect effect on performance, supporting the relevance of distinguishing between effort and performance. This study describes that next to the often-mentioned gold (pecuniary), ribbon (career), and puzzle (personal) drivers, there is a fourth distinguishable category of motivations with a moral nature. Interestingly, this study finds that moral motivations are relevant for performance in all domains and have their largest effect on performance in the culture and well-being domains, two domains of knowledge valorisation that have been underserved in previous studies. By investigating the desired change in effort for each output domain, this study highlights that scientists may perceive both competitive and synergistic effects of efforts in the different output domains. In addition, this study found that previously described entrepreneurial orientations only influence effort in the knowledge and economy domain but do not influence current or desired effort in the cultural and well-being domains. Finally, these results indicate that despite common belief, pecuniary motivations have a positive relation with performance in the knowledge domain as well as in the economy domain.

The study identified a new category of moral motivational drivers and confirmed it was distinct form the other types of motivation through a PCA. While many studies have mentioned at least one aspect of moral motivations, such as improving the quality of life (Ballabeni et al. 2014; Dijkstra et al. 2015), contributing to the economic growth of a country (Fini et al. 2009) and improving products or services for society (Closs et al. 2013), these aspects have not been integrated into a separate category of motivational drivers. Consequently, this category of motivational drivers was not adopted in earlier studies (Lam 2011; Olmos-Penuela et al. 2015).

Only very recently has a study identified a similar category of motivations and highlighted the importance of pro-social behaviour for the frequency with which researchers engage in knowledge valorisation activities (Iorio et al. 2017). This study supports the importance of moral motivations for increased efforts in the cultural and well-being domains and additionally finds a negative correlation between moral motivations and time spent on activities in the knowledge for knowledge domain. Moreover, the positive direct effect of moral motivations on performance in all four domains, and especially the culture and well-being domains, indicates that this type of drivers may positively influence the quality of academic engagement (Bonner and Sprinkle 2002).

With the lowest median score of all four motivator categories, this study confirms that in general money is a weak motivator for scientists. However, it also finds that this type of motivation is positively correlated with performance in the knowledge domain as well as the economic domain, which is in contrast to common belief (Lam 2011). The positive relationship between pecuniary motivations and activities within the economy domain (e.g. patenting, start-up companies) is well-described in literature (Geuna and Nesta 2006; Rizzo 2015). This study adds to this literature by finding a small but positive relationship between pecuniary sensitivity and performance in the knowledge domain. The causal direction of this relationship cannot be captured with this study's cross-sectional research design and is therefore still unclear. Although some researchers have highlighted that pecuniary incentives are more important for late-stage researchers who have already proven themselves in the knowledge domain (Janger and Nowotny 2016), an alternative explanation could be that pecuniary sensitivity might lead to higher performance in the knowledge domain via goal setting. Pecuniary sensitivity might signal academics' awareness of the quantitative assessments that are more prominent in universities today and as such lead them to set (challenging) goals with regards to their performance and to engage in efforts of higher quality in order to reach these goals (Locke et al. 1981). This is in line with academics

engaging in patenting activity as a means to signal academic quality (Göktepe-Hulten and Mahagaonkar 2010) and with reasoning from other scholars highlighting that highly productive scientists might be successful due to their positive perspective on economic activities (Davis et al. 2011) . The generally accepted notion that pecuniary factors are not important for the academic performance of scientists might be the result of many previous studies looking at motivation for certain behaviours retrospectively (Perkmann et al. 2013) and in isolation from performance and (Baldini et al. 2007; Closs et al. 2013; Hayter 2011, 2015; Lam 2011). This study took a different approach by questioning researchers on the extent to which different motivational factors were important to them and subsequently on how they performed in different domains. This has circumvented the risk of answers based on social desirability and implicit theories of self at least to some extent (Podsakoff et al. 2003).

Performance in the economy domain is positively associated with all types of motivation, indicating that it is a mistake to assume that performance in this domain is solely driven by pecuniary motives. This positive association substantiates the theorem that academics are only successful in this domain when they remain distinguishable from firms and do not focus merely on pecuniary outcomes, in order to fuel the virtuous cycle between economic activity and academic productivity (Azoulay et al. 2009; Jain et al. 2009). Interestingly, although career motivation is generally considered an important motivator for academics (Arzensek and Kosmrlj 2014; Beyhan and Rickne 2015; D'Este and Perkmann 2011), this type of motivation was only positively related with performance in the economy domain. The particular importance of career motivation for performance in the economy domain might be explained by the additional opportunities this domain offers for furthering academic careers, for example, by building a larger professional network or providing access to resources for research (Hayter 2015). In contrast, effort in this domain is mainly driven by pecuniary drivers. This differential effect of motivations on effort and performance might provide a rationale for transactional patenting activities being primarily driven by personal and career motivations ((Göktepe-Hultén, 2010) Gulbrandsen 2005) and time intensive spin-off creation being highly driven by pecuniary motivations (D'Este and Perkmann 2011).

For all four domains, effort was a positive predictor of performance. The entrepreneurial orientations that were described in previous studies (Lam 2011) were found to be relevant for time spent on the knowledge and economy domains but not the culture and well-being domains. More importantly, this study highlighted that scientists may perceive a balance between their efforts in the knowledge domain and their efforts in the other three domains, like communicating vessels. Scientists who wanted to decrease their effort in the economy or well-being domain aimed to increase their efforts in the knowledge domain but not decrease their efforts in any of the other societal domains. This may indicate that scientists only perceive competitive pressure between efforts on the knowledge domain and efforts in the societal domains, but no such pressure between the individual societal domains. In contrast, there may even be a perceived synergistic effect of efforts in the societal domains, since scientists who aimed to increase their efforts in the economy or well-being domain also aimed to increase their efforts in other non-academic domains. These findings are consistent with previous research that highlighted the complementarity of different knowledge valorisation activities (Grimpe and Hussinger 2013; Hayter 2015; Landry et al. 2010).

5.2 Control variables

In line with recent studies in this field (Li et al. 2017), we found no relation between the fundamental or applied nature of the research and performance or effort in the economy domain. Only in the well-being domain did more applied research correlate with more effort and a better performance, corresponding with previous evidence that applied researchers engage more actively with societal stakeholders (Olmos-Peñuela et al. 2014). This suggests that the applicability of the research is not a pressing factor on knowledge valorisation *per se* (D'Este et al. 2013), but may influence the type of valorisation activities that researchers are most likely to engage in. In line with previous research, we found that men spend more time on activities within the economy domain than women (Tartari and Salter 2015), although these effects do not result in differences in performance. In contrast with previous studies, we did not find an effect of gender on performance in any of the domains (Azoulay et al. 2007; Murray and Graham 2007). Professors were more likely to be motivated by moral motivations and made a larger effort on the well-being domain than non-professors, but no other differences were found in motivation or effort between both subgroups. This is consistent with the homogeneity in personal motivations that has been described before (Azoulay et al. 2007). In contrast to previous studies, this study found no effect of years of experience on effort in any of the domains, although these effects might be skewed by the experienced sample in our data set (Azoulay et al. 2007). The positive correlation between performance in the four different output domains is consistent with previous literature (Bekkers and Bodas Freitas 2008; Gulbrandsen 2005; Haeussler and Colyvas 2011). The positive association of professorship with performance in all domains is conform expectations and has been described before specifically for performance in the cultural domain (Bentley and Kyvik 2011).

5.3 Strengths and limitations

This study synthesised the body of literature on motivational drivers into four groups of motivational drivers. Statistical analysis confirmed that these components each had an internal consistency well above the 0.6 cut-off value. The scale items used for the motivational and performance measures are provided in the Supplementary Materials, providing a frame of reference for future studies (Perkmann et al. 2013).

While providing insight in the extent to which individual motivators are related to effort and performance in a broad range of knowledge valorisation activities, this study also has a number of limitations. First of all, the cross-sectional nature of the study calls for caution when interpreting the causality of the correlations. In addition, different motivational drivers may play a role in different stage of societal impact (i.e. knowledge production, knowledge exchange, knowledge use, and earning capacity). Future studies would therefore benefit from a longitudinal set-up, providing in-depth insight into how motivational drivers, effort, and performance influence each other over time in different stages of societal impact.

The clear focus of the study on the Life sciences sector within the Netherlands controls for factors related to geography and field of study but simultaneously should lead to caution when extrapolating these results to other settings. That being said, this focus enabled us to explore the differential effect of motivational drivers and effort on performance in different output domains in a rather homogenous research setting. While controlling for individual aspects, such as

entrepreneurial orientation, years of experience, fundamental or applied nature of the research, gender and professorial status, the study does not control for a wide range of institutional variables that might also influence performance. Such aspects include organisational factors, such as support from the department (Large et al. 2000), quality of the department (Ponomariov 2008), and the presence of a supporting infrastructure (Markman et al. 2005). Future research can build upon the findings of this study to extend our understanding of how motivational drivers, effort, and performance are mediated by these institutional factors. More importantly, future studies should further investigate the relationship between motivational drivers, ability of individual academics, intention (Goethner et al. 2012), and peer influence (Tartari and Breschi 2012) to fully grasp how and why academics engage in knowledge valorisation activities with differential success.

Circumventing difficulties in assessing performance via standardised indicators, this study used self-rated performance as a measure for performance and checked for correlation with a limited number of standardised indicators. This enabled full anonymisation of the respondents and circumvented many of the drawbacks encountered with metrics and indicators. Future studies can build upon these findings and link survey records with data from other sources for improved understanding and robustness of measurements, although such approaches have biases on their own as well. In addition, it is important to note that some of the items on the list of performance measures have been used as input variables in other studies, for instance, in studies investigating the impact of network relationships on knowledge transfer performance (Owen-Smith 2003). Indeed, knowledge valorisation performance is a synergistic effort and different output variables may in turn serve as predictor for subsequent performance.

5.4 Implications

This study clarifies how different motivational drivers influence effort and outcome within four distinct performance categories for the societal impact of knowledge. It shows that motivational drivers differentially impact performance and additionally suggests that differences between academics may lead to distinct performance profiles. Further research should study the different societal orientations of academics, how they develop over time and during careers and how academics can be optimally motivated and supported to contribute to a broad societal impact of knowledge. Conceptually, this article argues for a distinction between effort and performance as a valuable one in studies on academic engagement. As a practical implication, it supports the argument to spread responsibilities for exchange with different societal domains among individual professors, in line with their own interests and motivations (Janger and Nowotny 2016) rather than forcing unwilling scientists to fit into specific channels of academic engagement (Berggren 2017).

Supplementary data

Supplementary data is available at *Science and Public Policy* online.

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