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'Gold', 'Ribbon' or 'Puzzle': What motivates researchers to work in Research and Technology Organizations

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ABSTRACT

This paper employs the motivational trichotomy of financial rewards, reputational rewards, and intrinsic satisfaction (gold, ribbon, and puzzle) to analyze the role of motivation in the context of research and technology organizations. This research is based on a case study that used an online questionnaire survey of 421 scientists from a large multi-technology Research and Technology Organization. The paper draws from previous work on scientists' orientations toward outcomes and exploitation of research results and finds that the typology of motivational schemes differ. In the study's context, our analysis did not find advancing academic research to be the main motivator, but rather being able to exploit results. However, within the exploitation mode, the results show that all four factors, gold, challenge, engineering, and basic research, motivate researchers' activities. The study highlights the Research and Technology Organizations' differences compared to universities. The findings also suggest that the role of grand societal challenges is emerging as a distinct motivator, aside from a basic research-oriented advancement of science.

1. Introduction

Debates around the changing nature of work in the university sector have been ongoing (Berman, 2011; Johnson, 2017; Mirowski, 2011). Furthermore, with the debate on public sector organizations to quantify performance and accountability (Boston, 1996; Hood, 1995; Jackson and Lapsley, 2003; Verbeeten, 2008), the discussion around research organizations has centered on the shift of focus in academic work toward university-industry activity and research commercialization (D'este and Perkmann, 2011; Lam, 2011; Liao, 2011; Welsh et al., 2008). Although academic work has long had a foothold in commercial activities (Mowery et al., 2015), the rise of broader involvement of academia in commercialization has been a more recent trend. In universities, pure academic and academy-industry work can exhibit a tension in which organizational goals and researcher motivations clash. The primacy of scientists' self-motivation is a central factor in alignment with organizational goals, and the motivational schema extends beyond financial incentives (Lam, 2011). Organizational culture seems to play a significant role in public research organization engagement more broadly in the innovation system (Van Lancker et al., 2019). While research has extensively debated the dynamics of universities' strategic goals and scientists' motivations to engage with different activities (Bhullar et al., 2019; Hayter et al., 2018; Hottenrott and Lawson, 2017; Würmseher, 2017), studies have neglected to look at the Research and Technology Organizations (RTO), where the mission statement differs significantly.

RTOs are an important part of the innovation system in many industrialized countries. The organizations serve as publicly funded knowledge pools and technology transfer organizations, accelerating innovation and economic development (Mazzoleni and Nelson, 2007; Nelson, 1993). Despite their important role in the innovation system, analyzes of RTOs in innovation systems are scarce, except for a narrow body of literature on public RTOs and government laboratories (e.g. Crow and Bozeman, 1987). As the emphasis on mission-driven research calls for broader societal and commercial utility of research (Cagnin et al., 2012; Mazzucato, 2018), it also challenges the traditional roles and rationales of universities, RTOs, and industry in innovation dynamics. While in the university sector, scientists can compartmentalize academic research and commercial activities, RTOs often operate with a stricter model in which the publicly good nature of research is secondary to the ability to commercialize results. This is often built into the RTO's funding scheme, which varies significantly between RTOs, where a significant portion of financing should come from commercial research,

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ventures, or immaterial property. As the share of funding from public sources decreases, the importance of commercial activities takes center stage in organization objectives. The different organizational motives of RTOs, compared to universities, create a different tension between the self-motivation of a scientist and organizational objectives. RTOs' strong incentive for emphasizing the mission-oriented and utility of research can limit scientists' ability to focus on the intrinsic motivations of scientific research, pushing researchers toward research activities for application and commercial exploitation.

The present study revisits the extrinsic and intrinsic motivations of scientists in a RTO setting. This paper attempts to answer two distinct research questions. First, what are scientists' orientations toward RTO-industry links, and do these differ from universities' findings. Second, how do motivators vary among RTO scientists according to their attitudes and beliefs. Departing from the work of Lam (2011) the study examines the concepts of financial rewards, reputation, and career rewards, and intrinsic satisfaction, or "gold", "ribbon" and "puzzle" (Lam, 2011; Levin and Stephan, 1991; Stephan, 1996; Stephan and Levin, 1992), to examine if the motivational schema of scientists differs when the organizational objectives of the public research organization are shifted from the university type to a RTO. The framework of the study builds on understanding motivation, particularly motivation in the research context. Similarly to Lam (2011), this study is based on self-determination theory (SDT) (Ryan and Deci, 2000b), which is founded on the idea that human behavior and response to different rewards are based on an agreement with personal values and those of the activity. Motivation is one of the most critical elements affecting work performance, but at the same time, it is one of the most difficult to understand (Manners et al., 1983).

2. Background

2.1. Motivations of researchers

Motivation is a psychological phenomenon that initiates our behavior (Ryan, 2014) and encompasses all aspects of activation and intention (Ryan and Deci, 2000a). Motivation determines "the intensity, duration and direction of an action" (Jindal-Snape and Snape, 2006). Motivation is an individual phenomenon, and the degree of motivation depends on how the individual perceives a particular task, activity, or assignment (Katz, 2005). Self-determination theory posits that motivation can be categorized into intrinsic and extrinsic motivation based on the underlying reasons behind actions (Deci et al., 1985). Furthermore, motivation can be seen as a continuum from amotivation, a state where there is no intention to act at all, to intrinsic motivation. In between amotivation and intrinsic motivation, external motivation varies in terms of how autonomous the behavior is (Ryan and Deci, 2000b).

Intrinsic motivation is the act of doing something because of the satisfaction gained from performing the activity. In extrinsic motivation, behavior is influenced by the outcome of actions. An action is carried out to achieve something, and behavior has instrumental value (Ryan and Deci, 2000b). Intrinsic and extrinsic motivation can be positively correlated (Gagné and Deci, 2005). Under specific circumstances, rewards can have a neutral or even a positive impact on intrinsic motivation and creativity and lead to motivational synergy (Amabile and Hennessey, 1998). These situations require the rewards to be carefully selected. The fullest potential of motivation can be achieved when motivation is primarily intrinsic but complemented with appropriate extrinsic factors (Hebda et al., 2007). This said, providing extrinsic incentives can sometimes undermine intrinsic motivation, often referred to as crowding effects (Frey and Oberholzer-Gee, 1997).

Motivation is the driving force behind creativity and innovation (Amabile, 1998; Amabile and Hennessey, 1998). High motivation in itself does not guarantee high performance, since experience, skill, and capability play a central role in overall performance (Jindal-Snape and Snape, 2006). Motivating scientists differ from traditional performance-related motivational practices (Manso, 2011). Since researchers' work is often flexible and unpredictable by nature, they often have high autonomy, which simultaneously supports and requires intrinsic motivation (Pogrebnyakov et al., 2017). Despite the extensive interest and research related to work motivation, motivation in the research environment has received very little attention (Ryan, 2014). However, intrinsic motivation is known to be especially important for researchers (Koskialho, 2017), as creative tasks require intrinsic motivation (Osterloh and Frey, 2000).

Understanding scientist motivation requires considering a large mix of motivational factors, and having a holistic understanding is central (Lam, 2011; Sauermann and Cohen, 2010).

According to Lam (2011), which is consistent with Shmatko and Volkova (2017), there are three factors related to scientist's motivation: "gold, ribbon and puzzle". "Gold" refers to financial gains, (i.e., money). "Ribbon" is associated with fame and glory, such as career advancements and building a reputation. "Puzzle" refers to the satisfaction related to the research itself, including the creation of new knowledge or solving problems. According to Lam (2011), scientist motivation consists of different combinations of these three motivational factors. Studies by Lam (2010, 2011, 2015) differentiate researchers based on their professional orientation (i.e., their motivation for science and their attitude towards knowledge commercialization). Lam et al. categorizes researchers into traditional, entrepreneurial, and hybrid researchers, describing the different scientific values and underlying factors that eventually affect researchers' motivation. The traditional researcher is motivated by a "ribbon," through building a reputation and advancing their career. These "traditionalists" believe that knowledge commercialization is at odds with the fundamental nature of science and serves only as a necessary means to acquire funding and keep up with research activities. The modern entrepreneurial researchers believe in the collaboration of science and business and consider knowledge commercialization to be an inherent part of science, as it is simply one way of benefiting from scientific knowledge. Consequently, entrepreneurial researchers put high value both on the research activity (the "puzzle") and on the possible financial gains (the "gold") (Lam, 2010; 2015).

Hybrid researchers are a combination of traditional and entrepreneurial researchers (Lam, 2010; 2011; 2015). One can differentiate between two types of hybrid researchers, depending on their perspective regarding the traditional or entrepreneurial viewpoint. The first hybrid type, traditional hybrids, share the strong academic passion of "traditionalists." However, traditional hybrids recognize the need for industry collaboration for the good of science (Lam, 2010). The other type of hybrid, entrepreneurial hybrids, believe in the modern view of science-business collaboration, but share the traditional commitment to core scientific values (Lam, 2011). Entrepreneurial hybrids share traditional researchers' desire for reputation ("ribbon") as well as the entrepreneurial researchers' intrinsic motivation toward scientific problem-solving ("puzzle") (Lam, 2015).

Scientists are highly self-motivated (Jindal-Snape and Snape, 2006), and most researchers choose their career path purely out of curiosity (Joynson and Leyser, 2015). Self-fulfillment and the possibility of improving personal skills and competencies is what keeps researchers going (Shmatko and Volkova, 2017). People who become researchers want to improve their understanding of the world, make new scientific discoveries and use them to benefit society (Joynson and Leyser, 2015). In addition, experts want to feel that their work is contributing to something grander (Koskialho, 2017). This is illustrated in the work of Van De Burgwal et al. (2019), where the "gold", "ribbon" and "puzzle" approaches are extended by introducing a "moral" motivation. This is described by the authors as a distinct motivation to create societal impact through knowledge. Furthermore, the authors explain that "moral" motivation is broadly embedded in research, regardless of discipline, but emerges in different ways. In a similar study, Iorio et al. (2017) describes a "pro-social mission" motivation that focuses engagement on local communities and social well-being. D'Este et al. (2018) also demonstrated the importance of looking at the impact created by science more broadly, namely scientific, economic and societal. It is clear that tensions can emerge between different motivations and D'Este et al. (2018) highlight the importance of productive collaboration resulting in broad impacts of knowledge.

Overall, material aspects, such as salary and research funding, are considered necessary resources that researchers need to accomplish something and is not the primary reason for their work (Shmatko and Volkova, 2017). Amabile (1998) argued that money does not necessarily prevent creative behavior, but certainly does not increase it. Using money as a motivator can hinder creativity, especially when people feel like it is used as a means to control their performance (Amabile, 1998). In addition, using material incentives as a motivator can have negative effects on the community and its spirit, reducing collaboration as well as the exchange of knowledge and ideas (Shmatko and Volkova, 2017). Therefore, supporting intrinsic motivation is especially relevant in the case of experts (Koskialho, 2017). When focusing on academic engagement beyond the scientific community, it should be noted that engagement is independently driven by scholars and often defined by personal characteristics (Perkmann et al., 2013). Perkmann et al. (2021) showed that these characteristics are related to scientific productivity, academic and commercial experience, training and gender. While the roles and motivations of individuals are key, the organizations still have an important role in creating context (Sánchez-Barrioluengo and Benneworth, 2019). Additionally, the processes of engagement vary across industry and discipline (Meng et al., 2019).

Motivating research with operational motives rather than the intrinsic purposes of science is challenging (Veletanlić and Sá, 2019). Jindal-Snape and Snape (2006) conducted a study of scientists' motivation in a government research institute. They discovered that the most motivating factors for scientists were curiosity, good practice, high-quality science, and making a difference. Furthermore, the factor, making a difference, aligns with Van De Burgwal et al. (2019) and Iorio et al. (2017) pro-social motives, which are also highlighted by Ramos-Vielba et al. (2016). De-motivating factors included collaboration problems, competition, and a lack of feedback and recognition from management. An interesting discovery was that all the motivational factors were primarily intrinsic. (Jindal-Snape and Snape, 2006) Consequently, Jindal-Snape and Snape (2006) suggested that these types of organizations should focus on creating an environment that supports intrinsically motivated scientists, thereby helping them to perform at their best. Examples of recommendations for such organizations include: trying to eliminate (or at least reduce the influence of) de-motivating factors, providing opportunities to network, providing scientists with constructive feedback, and considering possible non-financial rewards.

2.2. Research and Technology Organizations

The concept of RTO refers to a broad and heterogeneous category of organizations with a variety of legal forms and governance models. Despite their heterogeneity, RTOs share functional specificity, as they aim to bridge the gap between basic science and market solutions, often referred to as "innovation intermediaries" (De Silva et al., 2018). They are distinct from universities and enterprises but have close links with them, as well as with local, regional, and national governments. Hales (2001) defined the relationship between RTOs providing a service to firms in support of scientific and technological innovation, while remaining integrated in the scientific process. A defining characteristic of RTOs is that they receive a substantial share of their funding from both private and public sources (Hales, 2001). Their funding may come in the form of institutional block funding from governmental bodies, bidding for competitive project funding, competitive contract research for firms or governments, or bilateral collaborative research with industry (EARTO, 2015; Hales, 2001; Leijten, 2007). Many RTOs also receive part of their resources from licensing their immaterial property rights or through participation in spin-off firms (Leijten, 2007).

Compared to universities, public research centers, such as the French National Centre for Scientific Research, Spanish National Research Council, National Research Council of Italy, or the academies of sciences in Eastern European countries (Sanz-Menéndez et al., 2011), RTOs are more focused on applied research (van Lente et al., 2003) with a technological focus De Silva et al. (2018). RTOs "...are distinctive, mission-oriented R&D organizations, which perform key functions in European innovation systems and exhibit characteristic strengths" (EURAB, 2005). Their "core mission to harness science and technology in the service of innovation, to improve quality of life and build economic competitiveness" (EARTO, 2015). The functions of RTOs are related to development work and basic research, certification and standards, and the provision of research facilities and contributing to technology transfer (Loikkanen et al., 2011; PREST, 2002). RTOs are considered important technology transfer agents in national innovation systems because they have a distinctive role in research collaboration with industry (Albors-Garrigós et al., 2014). These actions mostly focus on the exploratory phase (Landry et al., 2013), relying heavily on the scientific background of scientists in RTOs. As shown by Zaichenko (2018), there is a positive relationship between a RTO's scientific publications and its ability to work as an effective intermediary between basic research and industrial solutions.

Historically, RTOs have been dependent on government budgets and have pursued a mainly scientific mission. Today, RTOs are increasingly working on research or development for and with firms and are able to leverage their knowledge to attract private funding through contract research. The interaction between public research organizations and (local) industry substantially adds to the innovative performance and economic development of a region or country. The total scale of contract research in a RTO is an indication of the importance of this targeted knowledge transfer to industry.

Changes in innovation dynamics have affected the role of RTOs and the entire research and innovation system. Although systems of public research differ depending on the national context, there are several converging trends that are similar for these organizations globally (Cox et al., 2001; Cruz-Castro et al., 2012; Larédo and Mustar, 2004; Loikkanen et al., 2011; 2013; Sanz-Menéndez and Cruz-Castro, 2003). In particular, the emphasis on mission-driven innovation blurs the boundaries between universities, research institutes, and industry (Gibbons, 1994). Therefore, an innovation system is expected to evolve toward a greater degree of inter-organizational collaboration, which emphasizes value co-creation (Vargo and Lusch, 2004; 2008) and an innovation ecosystem's perspective (Kumar et al., 2015; Suominen et al., 2019; Williamson and De Meyer, 2012). As noted by Readman et al. (2018), "RTOs are practitioners in the art of collaboration." Emphasis on the intermediary role, emergence of customer orientation, an increase in commercial production of service, and development of business competency appear to be common challenges faced by RTOs. These changes influence the roles, management, and competitive position of RTOs and have forced them to renew their strategies and business models and create pressure to show how investments in RTOs generate business success, welfare, and economic growth.

3. Data and method

3.1. Sample and descriptive data

An online questionnaire survey was implemented in late 2019. The target population of the survey were researchers working at the case study RTO, namely, VTT Technical Research Centre of Finland. The researchers received e-mail addresses for all researchers working at the RTO (N=1318). The sample was selection was based on the individual employees' role description, enabling the questionnaire to only target RTO employees working directly in the role of a scientist. After a successful test of the survey (N=10), it was distributed via e-mail using a

Table 1
Typology of research between different motivational schema. Questions based on Lam (2011).

	First Best	First best (%)	Second best	Second best (%)
I believe that academia and industry should be distinct, and I pursue success strictly in the academic arena	10	2,39 %	15	6,91 %
I believe that academia and industry should be distinct, but I pursue industry linked activities mainly to acquire resources to support academic research	18	4,31 %	25	11,52 %
I believe in the fundamental importance of academic-industry collaboration, and I pursue industry linked activities for scientific advancement	184	44,02 %	99	45,62 %
I believe in the fundamental importance of academic-industry collaboration, and I pursue industry linked activities for application and commercial exploitation	206	49,28 %	78	35,94 %
	418		217	

Table 2
Created categories based on respondents answers to the questionnaire.

Respondents first best	Respondents second best	Count	%
"Hybrid"	None	83	23, 45%
"Entrepreneurial"	None	114	32, 20%
"Hybrid"	"Entrepreneurial"	74	20, 90%
"Entrepreneurial"	"Hybrid"	83	23, 45%

Table 3
Principal component analysis of 12 motivational factors.

	Factor			
Question	1	2	3	4
Increasing the stock of useful knowledge, even if the knowledge can not be directly applied				0.704
Training skilled persons			0.814	
Creating new tools, scientific instrumentation and analytical methodologies			0.767	
Forming expert networks and stimulating interaction	0.624		0.413	
Helping industry and stakeholders to solve complex problems		0.689		
Creating new firms	0.530			
Increasing funding and other research resources				0.595
Application and exploitation of research results		0.783		
Creating opportunities for knowledge exchange and transfer		0.507		0.418
Building personal and professional networks	0.609			
Enhancing the visibility of your research	0.673	0.352		
Increasing your personal income	0.762			
Kaiser–Meyer–Olkin Measure of Sampling Adequacy.	0.744			
Bartlett's Test of Sphericity				
Approx. Chi-Square	732,308			
df	66			
Sig.	,000			

personalized link generated by the system. The respondents were given two weeks (14 days) to complete the survey. One week after sending the survey, an e-mail reminder was sent to all recipients who had not already completed the survey. Six days later (one day before the survey closed), a final e-mail reminder was sent to the remaining recipients who had not completed the survey. After the reminder, we received 421 responses. Hence, the final sample was 32% of the total population. To control for response bias, the descriptive variables were evaluated against information at the company level. This evaluation showed that there was no significant variation in the response rates across disciplines, gender or experience.

From the survey respondents, two-thirds are male and one-third are female. The gender distribution of this study represents the gender distribution of all researchers in the case organization fairly well (29% female and 71% male). The educational background of the respondents is, in most cases, either a doctoral degree (48.5%) or a master's degree (50.4%), with the rest being bachelor's degree or lower. This is representative of the total population. In the case organization, 43% of researchers have a doctoral or licentiate degree, 54% possess a master's degree, and 2% have a bachelor's degree. The educational background of the remaining 1% is unknown. Due to the distribution of the variable across categories, we transformed the variable to a dichotomous variable if the respondent had a doctoral degree. We also identified the extent of the respondents' experience in research. Using 5-year increments, respondents were divided by their experience. Altogether this was broken up into eight categories. Seven of these had a percentage of ten or more respondents, and the largest experience bracket, 35 years or more, included only seven percent of respondents. This variable was binned to create a narrower ordinal variable.

3.2. Main variables and analytical approach

The survey questionnaire contained 15 questions on various aspects of scientists' work, divided into three categories: background questions, questions related to research teams, called nodes at the case study RTO, and questions related to researcher motivation. The main variables used in the quantitative analysis are derived from the questions concerning: a) the nature of their involvement in different types of industrial links, b) their value orientations toward academia-industry interface, and c) the factors motivating them to engage with industry.

We replicated the approach of Lam (2011), acquiring scientists' attitudes and beliefs about academic-industry collaboration and the legitimacy of commercial work against the organizational backdrop. The categorization confirmed by Lam through interviews and surveys places scientists in two polar values, "traditional" and "entrepreneurial", as shown in Table 1. Using four categories, the respondents were asked to place themselves in any class that best describes them. Respondents were also given the option to indicate a second best option. This second option is important, as Lam demonstrated that some interviewees struggled to place themselves into one category. While Lam focused on the first best answer, we used both the first best and second best to inform the analysis.

The central questions relating to this analysis focused on asking respondents questions about different research-related motivational factors. These were split into two sets of questions, ranked by using a five-point Likert scale. The respondents were first asked to evaluate the overall value they perceive coming from research work. The question is based on the study by Salter and Martin (2001), where the authors defined the categories as outcomes of research. The second set of questions focused on the respondent's personal motivation for the commercialization of research. This set of questions were adopted from the Lam (2011) survey, which targeted scientists from various research universities in the United Kingdom. Lam's survey also includes a question related to motivational factors affecting researchers' motivation to engage in industrial links. The focus on motivation is important to extend beyond institution-reported data toward independent activities (Perkmann et al., 2015). These questions were deemed central in the context of RTOs, where commercialization is deeply embedded in the

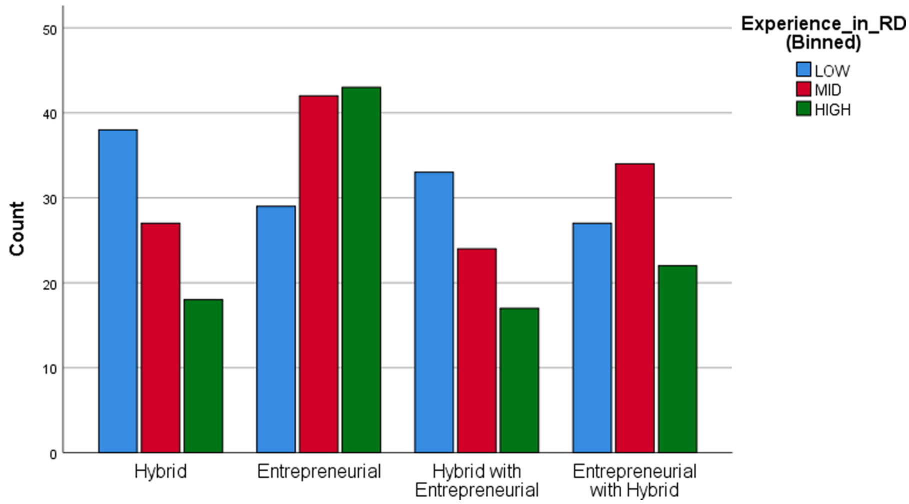

Fig. 1. Histogram of the relationship between experience in research and typology of research motivation.

mission statement. Slight modifications were made to the original questions, as shown in Table 3, to better fit the context of the case organization, an RTO. This is particularly important, as our focus was to extend our current understanding, focusing on universities in the RTO context.

This study used SPSS Statistics 26 software as the primary tool for the statistical analysis of the survey data. SPSS is used to derive descriptive statistics of the data as well to conduct principal component analysis (PCA). In analyzing the data, we assume no linear relationship between the variables. As suggested by Linting and van der Kooij (2012), we use a non-linear principal component analysis (NLPCA), or CATPCA procedure as in the SPSS statistical software, to analyze the categorical Likert scale responses. We saved the transformed variables from the CATPCA procedure in SPSS and submitted the transformed variables to linear PCA with Varimax rotation (e.g., Tabachnick and Fidell, 2001), as suggested in Linting and van der Kooij. This CATPCA based analysis procedure was done for variables shown in the Appendix. We also used the factors created by the NLPCA analysis in a regression model, with a variable focusing on the type of user, which was used to validate the assumptions made about the factors. The models were built on ordinal regression models using SPSS software. Finally, we calculated the mean values of the factors to analyze selected descriptive values.

Table 4
Factor labels with questions associated.

Factor	Factor name	Questions
1	"Gold"	- Forming expert networks and stimulating interaction - Creating new firms - Building personal and professional networks - Enhancing the visibility of your research - Increasing your personal income
2	"Challenge"	- Helping industry and stakeholders to solve complex problems - Application and exploitation of research results - Creating opportunities for knowledge exchange and transfer - Enhancing the visibility of your research
3	"Engineer"	- Training skilled persons - Creating new tools, scientific instrumentation and analytical methodologies - Forming expert networks and stimulating interaction
4	"Basic researcher"	- Increasing the stock of useful knowledge, even if the knowledge can not be directly applied - Increasing funding and other research resources - Creating opportunities for knowledge exchange and transfer

4. Results

One of the central questions in Lam (2010) was whether there is a typology between researchers from traditional and entrepreneurial viewpoints. These categories, even by Lam, were not seen as mutually exclusive, and one person would not belong to only one of the classes. However, in the original work of Lam, the categories were used as a hard classification to place respondents in a particular typology. Lam (2010) reporting the results of a similar exercise, one sees that researchers in the RTO in question have not associated with what Lam defined as "traditional" or "pragmatic traditional." Rather, the majority of respondents are associated with the "hybrid" and "entrepreneurial" scientist category. Even if we extend the analysis to look at respondents that reported a second best option, the two first-mentioned categories are of lowest representation. This can easily be justified by the mission statement of a RTO, which seems to translate the researcher motivation. Also, this suggests that there is a lower discord between self-motivation and organization mission statements, particularly compared to universities engaging in commercialization activities.

The low number of "Traditional" and "Pragmatic Traditional" respondents suggested that the focus should be on the "Hybrid" and "Entrepreneurial" scientists. To expand the view from the hard classification of a scientist to one of the categories, this study focused on the four categories: "Hybrid", "Entrepreneurial", "Hybrid-Entrepreneurial" and "Entrepreneurial-Hybrid". The categories were constructed from respondents identifying as only one category that are being treated as two categories, "Hybrid" and "Entrepreneurial". This was complemented by two classes combining scientists who reported a first best as "Hybrid" and "Entrepreneurial," but also gave a second best option as the other category. The identified four categories are shown in Table 2.

The categories are, by percentage, distributed relatively equally, except for the "Entrepreneurial" category, which is approximately 10% higher than other categories. Testing against the descriptive variables, the categories found one significant relationship. There is a significant relationship between the binned variable of research experience and perception toward research, $\chi^2(6, N = 354) = 14.395, p < .026$). This is depicted as a histogram in Fig. 1. The proportion of respondents who reported a particular category did not differ by gender ($\chi^2(3, N = 354) = 2.912$, $p > .05$), position in organization ($\chi^2(9, N = 354) = 12.647$, $p > .05$), or by educational level ($\chi^2(3, N = 354) = 5.607, p > .05$).

To determine if different motivational factors could be identified, if we can identify different motivational factors, 12 variables from the two questions were included in the analysis. First, a CATPCA procedure was run to produce the transformed variables used in the subsequent linear PCA. The produced four-factor solution explains 57.44% of the variance in the data. The number of factors was selected using an eigenvalue cutoff value of one. The resulting Rotated Component Matrices for the CATPCA analyzed datasets are shown in Table 3. A loading of 0.35 was used as a cut-off value for questions taken into the qualitative analysis of components.

The factors created by the four-factor solution suggest the existence of different base motivations for research. Factor 1, named here as "Gold," and aligning with previous research, is clearly motivated by financial reward. Factor 2, labeled here as "Challenge", highlights the possibility of solving grand challenges and transferring this knowledge to use. In this factor, there is a strong element of societal impact on the motive of conducting research. Factor 3, named "Engineer", appears to focus on the engineering ability to create novel tools and methodologies and educating others on these. Factor 4, named "Basic researcher", is really driven by the fundamental need to advance science and to secure resources for this purpose. Factor labels with associated questions can be seen in Table 4.

The factor scores were used to analyze more deeply the relationship between background variables. First, an analysis was performed using multiple nominal regression, whether the factors were statistically significant for the self-assessment of scientific motivation. The four classes seen in Table 2 were utilized, but none of the classes were statistically significant. Tests were conducted to determine if gender or education were statistically significant using binomial logistic regression, and if experience in research and development was statistically significant using ordinal logistic regression. From the variables, only experience in research and development was statistically significant. The less experience the researcher has the more likely they belong to Factor 2.

Discussion

Motivation is important regardless of the activity; arguably, it is even more so in research. We also know that context of the activity also plays a role in motivation. Extrinsic factors, such as organizational objectives, influence individual motivations. In an organizational setting, this can result in changing motivations for existing employees or attracting a specific type of individual to join the organization. The literature on universities has focused on the changing nature of work creating tension between self-assigned goals and organizational objectives, particularly with the increasing role of commercial activity. RTOs offer a different perspective on research in the innovation system, where the role of the organization has been linked to applied research and commercial activity, but is transitioning to include more towards large scale missions.

Lam's article looked at the typologies of research motivation through interviews and a survey. During the interviews, she noted a need to adjust the descriptions of "traditional," "pragmatic traditional," "hybrid," and "entrepreneurial" scientists. In the questionnaire test phase of our study, we received feedback on the typology suggesting that it is too restrictive and does not fully capture respondents' perspectives. However, our results make sense. As an RTO, the case study organization's mission does not focus on what Lam classifies as "traditional" or "pragmatic traditional" but is instead focused on applied science and, in particular, on having an impact on industry and broader society. The survey respondents placed themselves in either "hybrid" or "entrepreneurial" categories or a mixture of these. We can question whether this selection is based on a deeply rooted self-assessment or whether it is based on the organizational mission statement, which is visible in researchers' answers. An easy explanation is that the organization's mission attracts research talent with a particular set of motivations. While most of the background variables were not statistically important, it was notable that a solely "entrepreneurial" motivation seems to attract individuals with more research experience, aligned with the findings of Perkmann et al. (2021, 2013). Considering the wording in Table 1, researchers with more research experience focus on commercial exploitation, while researchers with less experience focus on scientific advancement. One might question whether this stems from a generational change in researchers, and also, whether the changing role of the RTOs is internalized by those with less research experience.

When considering the motivations of researchers in general and those in RTOs, we should question whether there is a difference. The RTO context Jindal-Snape and Snape, 2006 concurred with the more general notions highlighting curiosity, practicing good, high-quality science, and making a difference, all of which align with previous studies. The differences between Lam's findings regarding the motivational schemas from the university sector and the RTO in this study could be explained by the differences both in organizational objectives and more general objectives of research performance, which are also embedded into the mindsets of scientists in the organizations over time. Differences in internal performance indicators influenced by the expectations of the science community encourage the pool of researchers to strive towards different types of outcomes. Given this, both types of organizations are highly path dependent, limiting, for example, RTOs' capability to extend into the space of basic research. However, what might be more important is the fact that as the motivational schemas and thus the orientations of faculty at universities and RTOs differ so significantly, it can be challenging to find common ground and interests required for collaboration. This could ultimately lead to inefficiencies in the innovation system. RTOs should also consider whether the strong focus on hybrid and entrepreneurial approaches limits the organization to short-term utilitarian goals, which ultimately hinders their ability to renew and continue to generate valuable scientific and methodological knowledge. These findings highlight the challenges faced by an RTO, an innovation intermediary (De Silva et al., 2018), whose core strength is the ability to foster collaborations (Readman et al., 2018) in the exploratory phase (Landry et al., 2013), while still being able to conduct high-level research (Zaichenko, 2018). Further research should investigate in depth the ideal balance of motivations and competencies required to enable the RTO to fulfill its role, including promoting "the art of collaboration" (Readman et al., 2018) required in the mission-driven innovation system.

Lam's study focusing on the university context (Lam, 2011) used the trichotomy of "gold", "ribbon," and "puzzle" to explain research motivations. While this seems to be a practical classification of the motivational dynamics of research work, we can question, particularly given our findings on the general approach, whether this schema extends the university sector. This study sought to address this question using a set of 12 questions that focused on the crucial role of RTOs to interact with industry and tackle societal missions, as well as exploring the more general motives and outcomes of research. The four-factor solution that was produced partly aligns with the findings of Lam, but also adds new understanding. While Lam's typology of scientists did not fit in the RTO context, our results from the principal component analysis uncovered a schema fitting universities and RTOs alike. The principal components highlight a factor that emphasizes financial rewards ("gold"), but also account for the basic research-oriented researcher.

Adding to Lam's results, our analyses proposes a schema that focuses on solving industrial ("engineering") and societal challenges ("challenge"). The orientation towards solving challenges, be they industrial or societal, seems to be a clear extension of the findings of previous work. Aligning with Koskialho's (2017)) understanding, the ability to solve grand, concrete societal challenges seems to be important to the RTO typology. Research has shown that curiosity drives individuals to do research (Joynson and Leyser, 2015) and that being able to better oneself is high on the list of what keeps researchers going. (Shmatko and Volkova, 2017). It is clear that the motivational schema also includes an aspect of making the world a better place (Koskialho, 2017) that is not fully included in the "gold," "ribbon," and "puzzle" model of motivation. Our findings seem to reiterate the call for an extended model that includes "moral" (Van De Burgwal et al., 2019) and/or pro-social (Iorio et al., 2017) motivations. This suggests that future research should consider extending the existing theoretical framing of "gold," "ribbon," and "puzzle."

Overall, our study found important differences between Lam's results in the university sector and the results in RTOs. We know that RTOs have a distinctive, mission-oriented role to harness science and technology in the service of innovation (EARTO, 2015; EURAB, 2005) and that the functional schema for RTOs differs from universities (Albors-Garrigós et al., 2014; Loikkanen et al., 2011; PREST, 2002). This is also clearly visible in the motivation schema for RTO researchers. This reiterates the importance of the different roles in universities versus RTOs in the innovation system. Extending tasks that are better suited to RTOs to university settings seems to negatively impact innovation policy (Ejermo and Toivanen, 2018). Given this, policy should be based on a deep consideration of the role of different innovation instruments, such as universities and RTOs, and should be developed based on the outcomes each different organization is geared to deliver. For the RTO in question, we have observed a challenge-driven motivational schema that is strongly embedded and extends the "gold" and "intrinsic" motivations shared with universities.

Our study is limited by the fact that it was conducted in one RTO, which may limit the generalizability of the results. We note that RTOs are not a homogeneous group of entities, particularly when extending beyond Europe, thus our findings should be considered within their context. However, the sample size, drawn from the large, multi-technology RTO where the study was conducted, was relatively sizeable, which increases confidence in our findings. This being said, future research should consider extending the analysis to both the university sector within the case country and also to RTOs and inter-organizational (ecosystem) contexts globally to evaluate how our results extend beyond the contextual surroundings of this study.

CRediT authorship contribution statement

Arho Suominen: Conceptualization, Methodology, Software, Data curation, Writing - original draft, Writing - review & editing, Project administration, Funding acquisition. **Henni Kauppinen:** Methodology, Validation, Investigation, Data curation, Writing - review & editing, Writing - original draft, Formal analysis. **Kirsi Hyytinen:** Conceptualization, Validation, Investigation, Writing - review & editing, Visualization.

Appendix. Survey design

The survey begins with background questions (questions 1 to 7) that are obligatory for all respondents. The first six ask for information related to the respondent's gender (question 1), age (question 2), highest degree or level of school completed (question 3), discipline (question 4), years of experience in research and development (question 5), and the respondent's position in the organization, that is, whether they are senior, mid, junior, or support (question 6). In the second question, respondents are asked to indicate their age by choosing one of the listed age groups, which each span a ten-year interval (e.g., 30–39 yrs.) – this level of accuracy is sufficient for the purposes of this research. For the third question, the education-level alternatives provided are based on the Finnish educational system, as defined by the Finnish Ministry of Education and Culture. Since the case organization's personnel are highly international, question 3 includes the option to choose "Other" and type the degree, in case the corresponding alternative cannot be found amongst the predefined alternatives. For question 4, the English version of the disciplines is based on the Frascati classification of science and technology fields, as defined by the Organization for Economic Co-operation and Development (OECD) in 2006 (OECD, 2007). The same classification is recommended for universities' research and data collection activities by the Finnish Ministry of Education and Culture Hence, the Finnish classification of the disciplines has been recommended by the Finnish Ministry of Education and Culture and is based on the original OECD's Frascati classification Consequently, the list of disciplines in the English and Finnish versions of the survey are derived from the same original classification and are thus equivalent. In question 5, the respondent is asked to indicate how many years of experience they have in research and development by choosing between alternatives presented at five-year intervals starting from zero. In question 6, respondents are asked to chose which of the four alternatives (senior, mid, junior and support) describes their current position in the organization and provide a short description of the position to clarify what they mean.

In the final background question (question 7), the respondent is asked whether they belong to one or more self-organizing research groups, named substance nodes (yes/no). Question 7 divides respondents into those who belong to substance nodes and those who do not, which determines the questions that will be presented to the respondent. The respondents who belong to one or more substance nodes are qualified to answer the full survey and are thus presented with all the questions in numerical order. These respondents move onto questions related to substance nodes, beginning with question 8. In question 8, respondents are asked to name their substance node (or, in case they belong to several nodes, the node they feel the most committed to) by selecting the node from a drop-down menu. The listing is based on an existing list of registered nodes. However, the list of substance nodes that is provided may not include all existing nodes. Therefore, in case the substance node the respondent belongs to cannot be found in question 8, the respondent is asked to leave question 8 empty and type the name of their node in a text field presented in question 9. Since the respondent is asked to select only one substance node, questions 8 and 9 are not obligatory, and the respondent can name their node in either one of them. Either way, the respondent is instructed to answer the rest of the survey based on the node they have named. The information about which substance node the respondent belongs to is used to link the survey results to individual nodes, however, not to individual respondents.

The next substance-node-related questions, 10 and 11, are obligatory Likert scale questions. They include questions about the decision to join a substance node as well as about the operation and level of self-management of the node. Question 10 aims to discover the importance of different factors influencing the decision to join a substance node. The respondent is asked to indicate the importance of each motivational factor presented by selecting the most suitable option in the five-point Likert scale (very important, important, moderately important, slightly important, or not important). Question 11 includes statements regarding how the node operates and thus aims to discover how self-managing the node currently is. In question 11, the respondent is asked to indicate the level to which they agree with the statement using a six-point Likert scale (strongly agree, mostly agree, slightly agree, slightly disagree, mostly disagree, or strongly disagree). The decision to use a six-point scale instead of a five-point scale is based on the fact that in a six-point scale, the respondent cannot take a neutral stance. Instead, they must reflect on their beliefs and express an opinion. The statements in question 11 are derived from self-management theory. First, different attributes of self-management (autonomy, empowerment, information flow and transparency, team identity and purpose, and intrinsic motivation) were identified from existing literature. Based on these attributes, different statements were generated to discover to what extent these attributes exist in the currently operating substance nodes. The overall purpose of question 11 is to analyze the extent to which the attributes of self-management get realized in individual substance nodes and to determine which require further consideration. Finally, question 11 serves as a means to identify the substance nodes that are successfully self-managing and those that may require more support from the organization.

If the respondent answers question 7 by saying they do not belong to any substance node, the survey skips all the substance-node related-questions (questions 8 to 11) and guides the respondent to questions related to researcher motivation (questions 12 to 15). Questions 12 to 15 are the same for all respondents whether they belong to a substance node or not. Question 12 is concerned with the extent to which the

Table 5
Importance of different research-related motivational factors.

Please describe the importance of the following factors to your research:	Not important	Slightly important	Moderately important	Important	Very important
Increasing the stock of useful knowledge, even if the knowledge cannot be directly applied					
Training skilled persons					
Creating new tools, scientific instrumentation, and analytical methodologies					
Forming expert networks and stimulating interaction					
Helping industry and stakeholders solve complex problems					
Creating new firms					

Table 6
Respondent's personal motivation to cooperate with industrial partners.

Please describe the importance of the different factors below in your personal motivation to cooperate with industrial partners.	Not important	Slightly important	Moderately important	Important	Very important
Increasing funding and other research resources					
Application and exploitation of research results					
Creating opportunities for knowledge exchange and transfer					
Building personal and professional networks					
Enhancing the visibility of your research					
Increasing your personal income					

respondent plans his or her research strategy beforehand and the extent to which available research funding guides the respondent's research agenda. Question 12 includes two statements, and the respondent is asked to select the most suitable option from a five-point Likert scale (strongly agree, agree, neither agree or disagree, somewhat disagree, or strongly disagree).

Question 13 is concerned with the respondent's professional orientation. It is based on an existing survey question created by Lam (2010) to determine scientists' professional orientations. The question includes four alternative statements, and respondents are asked to choose at least the option that best describes them and if need be, a second best option. The four statements include opinions about the relationship between academia and industry, and respondents choose one that that best expresses their orientation. The purpose of the question is to place the respondent into one of the following four categories: "traditional," "entrepreneurial," "hybrid traditional," or "hybrid entrepreneurial" scientist (Lam, 2010). They are prompted to select either "1" or "2" from the corresponding drop-down menu to indicate the first best, and if needed, a second best option.

Question 14 (Table 5) aims to discover the importance of different research-related motivational factors to the respondent. Each of the factors is ranked using a five-point likert scale (very important, important, moderately important, slightly important, or not important). The question is seen in Table 5.

Finally, question 15 (Table 6) explores the respondent's personal motivation to cooperate with industrial partners. This question is adopted from Lam's (2011)) survey designed for scientists from various research universities in the United Kingdom. Lam's (2011)) survey includes a question regarding factors affecting researchers' motivation to engage in industrial links That question served the purpose of this study and was therefore replicated in the survey. However, slight modifications were made to the original motivating factors to better fit the context of the case organization – a research institute. Contrary to the majority of the survey questions, question 15 is not obligatory. In case the respondent's work does not include cooperation with industrial partners, the respondent has to be able to leave the question empty. Similar to question 14, question 15 includes different motivational factors and a five-point Likert scale (very important, important, moderately important, slightly important, or not important), which is used to indicate the importance of the different factors.

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