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University scientists' multiple goals achievement: Social capital and its impact on research performance and research commercialization

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ABSTRACT

This study conceptualizes a quadrant model characterizing four profiles by contrasting university scientists' multiple goals: research performance and commercialization. Since literature shows that these goals are conflicting but not mutually exclusive, social capital theory is drawn to test the influence of scientists' bonding, bridging, and linking social capital on their profile affiliation. Survey data from 1057 German scientists is utilized to estimate a multinomial logistic regression model relating scientists' profiles to the different forms of social capital. The results show that only 4.16% of the scientists achieve above-average research performance and also commercialize their research results, whereby all three forms of their social capital positively impact the achievement of these goals. Furthermore, bonding social capital positively relates to scientists with above-average research performance but no commercialized research results. Bridging social capital facilitates scientists to commercialize results, albeit with below-average research performance. In addition, an inverted U-shaped relationship between scientists' bonding social capital and their research performance is identified, suggesting that an excess of this form of social capital may impede scientists' ability to achieve multiple goals. The results are discussed and policy recommendations are derived.

1. Introduction

University scientists' primary goal is to conduct excellent research and distinguish themselves from other competing scientists through impactful contributions to scientific discourse (Grewal et al., 2008; Frenken et al., 2017). However, in recent decades, the variety of roles and functions performed by university scientists has increased significantly, especially in terms of industry and society outreach activities (Fromhold-Eisebith and Werker, 2013; Perkmann et al., 2013, 2021). Particularly, the desire to connect academics more closely with the industrial side turns the metaphor of the scientist in the ivory tower into an outdated image (Etzkowitz and Leydesdorff, 2000; Haeussler and Colyvas, 2011; Fritsch and Krabel, 2012). This includes a range of university-industry relationships in which scientists interact with private sector companies by selling or licensing generated intellectual property, founding a company themselves, or collaborating with companies (Bercovitz and Feldman, 2006; Bekkers and Bodas Freitas, 2008; Boardman and Ponomariov, 2009; Perkmann et al., 2011, 2021).[1] The active participation of universities in economic development has turned them into organizations with multiple goals (Holstein et al., 2018; Kotlar et al., 2018; Fini et al., 2019), which confronts scientists with the challenge of reconciling generating impactful research with the commercial exploitation of their results.

Research performance of scientists is frequently defined as the number of citations per year and publication in a given time-span, reflecting the impact their research has on the scientific discourse and succeeding research (Olmos-Peñuela et al., 2014). Research commercialization is a fundamentally different endeavor for academic scientists and challenges them to operate in a different context where knowledge is to be financially exploited (Cantner et al., 2024a). The pursuit of each goal is subject to different norms and reward systems, which makes balancing them a difficult endeavor for scientists (Ambos et al., 2008; Sauermann and Stephan, 2013). We already know that these goals are not mutually exclusive and that there is a relationship between outstanding research performance and commercialization activities by scientists (e.g. Geuna and Nesta, 2006; Siegel et al., 2007; Gulbrandsen and Thune, 2017; van Looy et al., 2006, 2011), indicating that some scientists can resolve the conflicts between those goals. This particular

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[1] This excludes the transfer of knowledge and technology to the public sector, although universities can also play a role in harnessing innovation in the public sector to improve its agency efficiency, effectiveness and performance (see e.g. Demircioglu and Audretsch (2019).

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type of scientist can be described as ambidextrous, because they achieve both goals: they generate impactful research and exploit the results commercially (Chang et al., 2016). However, how those scientists manage to achieve these multiple goals remains unclear. For the achievement of each of the goals, scientists' social capital seems to be an integral asset. It is the set of resources they can access and mobilize for purposive actions by drawing on the social structure in which they are embedded (Portes, 1998; Lin, 2017). Drawing on the knowledge and resources of scientific peers can give them competitive advantages in scientific competition while connecting with the industry side leads to a larger and more diverse pool of social capital (van Rijnsoever et al., 2008; Hayter, 2016b). Existing research has so far focused on how scientists achieve one of these goals (e.g. Chang et al., 2016; Broström, 2019), however, the literature is silent on the issue of what distinguishes scientists in their achievement of multiple conflicting goals and the role a diverse social capital plays in this context.

This study aims to fill this gap by conceptualizing a quadrant model characterizing scientists by contrasting their multiple goals of research performance and research commercialization. While there already are concepts categorizing scientists by their research orientation (Stokes, 1997), their orientation towards university-industry connections (Lam, 2010) or their collaboration strategies (Bozeman and Corley, 2004), there is no such concept characterizing scientists by their achievement of multiple goals.[2] In this study, I derive four profiles which distinguish scientists by their level of research performance within an intra-disciplinary comparison as well as by their extent of commercialized research results. Scholars have already investigated various influential factors on scientists' research performance, such as their work experience or their prior scientific training (e.g. Gulbrandsen and Smeby, 2005; Perkmann et al., 2011; Abramo et al., 2012; Broström, 2019; Gulbrandsen and Thune, 2017). Others have examined how organizational and individual resources affect scientists' research commercialization (e.g. Ambos et al., 2008; Chang et al., 2009, 2016; Sengupta and Ray, 2017). In this study, both literature streams are combined by a multiple goals perspective and the influence of different forms of social capital is added to empirically investigate their effect on scientists' belonging to one of the derived profiles. Bonding, bridging, and linking social capital are the three forms of social capital I deduce from social capital theory and apply to the university context (Granovetter, 1973; Putnam, 2001; Szreter and Woolcock, 2004). The analysis is centered around the individual scientist, and hypotheses related to the impact of each form of social capital on the scientist's profile are derived.

To test the hypotheses, I use data from a novel online survey. The survey, which was conducted in the German federal state of Thuringia between December 2019 and January 2020, collected information on scientists' commercialization activities and industry connections. The sample of respondents from ten universities is representative of Germany in terms of key characteristics. The survey data is combined with publication data for each respondent and data about each university's funding structure. The empirical analysis's main specification and robustness tests utilize multinomial logistic regressions.

The results show that with 4.16%, only a small fraction of scientists are ambidextrous, simultaneously performing above the average and commercializing their results. All three forms of social capital drive the achievement of both goals simultaneously. Impactful scientists with above-average research performance who do not commercialize research results are associated with their bonding social capital while commercializing scientists with below-average research performance draw on their bridging social capital. Furthermore, I show that the relationship between bonding social capital and research performance appears curvilinear. With an extensive degree of bonding social capital, its actual advantages can turn into disadvantageous effects.

The study contributes to the literature about scientists' research performance (e.g. Gulbrandsen and Smeby, 2005; Perkmann et al., 2011; Abramo et al., 2012; Broström, 2019; Gulbrandsen and Thune, 2017) and research ambidexterity in the university context (e.g. Ambos et al., 2008; Chang et al., 2009, 2016; Sengupta and Ray, 2017) by combining and enriching it with a social capital perspective. The conceptualization of scientist profiles and the empirical insights help categorize heterogeneous scientists by considering multiple goals (Holstein et al., 2018; Kotlar et al., 2018; Fini et al., 2019) and the role different forms of social capital can play in achieving them. This can guide policymakers in determining how to reconcile the desired goals and how to achieve them.

The paper is organized as follows. In section 2, I conceptualize a quadrant model contrasting scientists' goals of research performance and research commercialization to distinguish between four scientist profiles. Hypotheses are derived regarding the impact of various forms of scientists' social capital on their belonging to one of the profiles. Section 3 presents the data and empirical approach, followed by the results and robustness tests in section 4. Finally, I synthesize the main findings and discuss the main implications of the study in section 5.

2. Conceptual framework and hypotheses

2.1. University scientists' multiple goals

Universities are environments in which different activities take place to meet the manifold roles of today's higher education institutes (Etzkowitz et al., 2000). Besides the predominating objective of generating knowledge, scientists are also required to exploit their research results commercially (e.g. Etzkowitz et al., 2000; Siegel et al., 2003; Slaughter and Rhoades, 2004; Berghaeuser and Hoelscher, 2020). This leads to a duality of knowledge generated by universities, expanding scientific research on the one hand and enabling useable commercial applications on the other (Murray and Stern, 2007). Thus, universities, as significant actors, are vital in shaping the knowledge economy. With the expected outcomes of impactful research results and commercial output, universities are organizations with multiple goals (Holstein et al., 2018; Kotlar et al., 2018; Fini et al., 2019). This consequently affects the scientists working within these organizations: they have to work towards achieving those goals while simultaneously balancing their resources.

The goal of generating impactful research results is deeply embedded in the academic research system, which is characterized by freedom of research, an open science mentality, and the treatment of knowledge as a public good (Nelson, 1959b; Rosenberg, 1974). Knowledge is generated by the individual scientist for the sake of scientific progress, while the process of knowledge generation itself is determined by originality — a norm that entails the ambition to always search for the unknown to discover novel research results (Ziman, 1984). Scientists who discover and publish novel research results significantly contribute to the progress of science. This leads to gaining peer recognition and reputation, which is the currency of academic competition and puts individual research performance at the forefront of every scientist's academic endeavor (Dasgupta and David, 1994). Among scientists, there are those notable in particular for their visibility in the scientific community due to their strong contributions to advancing their research discipline. These scientists are, therefore, not necessarily characterized by high productivity in the form of frequently published output but by large citation counts, which Zeng et al. (2022) refers to as impactful scientists. This also gives them a competitive advantage in the acquisition of research funding, as the aim of funding agencies is to generate impactful research when deciding how to allocate their scarce resources (Tijssen et al., 2002; Laudel, 2006; Banal-Estañol et al., 2019).

The goal of research commercialization requires, in addition to the

[2] There is one study by Subramanian et al. (2013) focusing on industrial scientists instead of academic scientists, which categorizes them by their research productivity and their frequency of patenting to identify those scientists who create value for the firm.

production of knowledge, to exploit it commercially by treating knowledge as a private good (Dasgupta and David, 1994). This requires the scientist to apply different logic and norms that prevail in an industrial setting and are contrary to those in academia (Fini and Lacetera, 2010; Sauermann and Stephan, 2013). The value of new knowledge is derived from its commercial utilization and the reward is financial gain. These differences in how newly produced knowledge is used can lead to tensions that a commercializing scientist must manage (Gurdon and Samsom, 2010).

The missing link between those two goals is the ability to do both: outperforming research and commercialization of research results. Achieving both goals encompasses the academic attainments of an impactful scientist and a commercializing scientist. Such behavior can be coined as ambidextrous, a term originally used by management studies to describe organizations that can pursue two incompatible and conflicting goals simultaneously (Birkinshaw and Gupta, 2013). On the individual level, ambidexterity refers to the capability to achieve contradictory goals by switching between different mindsets and action sets (Bledow et al., 2009).[3] In the context of universities, this study follows the definition of scientists' research ambidexterity by Chang et al. (2016, p. 9) as the ability of academic scientists to "simultaneously achieve research publication and research commercialization at the individual level" and extends it by the criterion that these publications have created an above-average impact in the scientific community reflecting scientists' research performance. This is closer to the original definition of Birkinshaw and Gupta (2013) when it comes to pursuing conflicting goals simultaneously because, for university scientists, academic competition is not just about being productive but, above all, about being visible and valued. This means ambidextrous scientists can deal with tensions between these opposing endeavors, adapt to different roles, and refine and renew their knowledge, skills, and expertise (Mom et al., 2009).

2.2. Towards a quadrant model of scientist profiles

Even though the literature provides different classifications of scientist profiles (Stokes, 1997; Lam, 2010; Bozeman and Corley, 2004), no classification considers scientists' achievement of multiple goals. I develop a quadrant model to define profiles to contrast scientists' research performance with their research commercialization. Consequently, by contrasting these two goals, four profiles of scientists can be distinguished (see Fig. 1).

Normal scientists: The term "normal scientists" is derived from how Kuhn (1970, p. 10) defines and describes normal science: as "research firmly based upon one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice". Scientists in this profile represent the baseline in group comparisons and serve as an orientation when considering scientists who deviate from it. A below-average output of impactful research characterizes these scientists compared with better-performing scientists who deviate from the norm. Furthermore, normal scientists also do not deviate from the norm in terms of commercializing their research results to an above-average extent. The below-average research performance may be due to the fact that the scientists in this profile are still at the beginning of their academic careers and have yet to establish themselves in academia. Moreover, their research output may be high on a quantitative level. However, qualitatively, it focuses mainly on research questions that have been largely answered or on formalizing existing knowledge

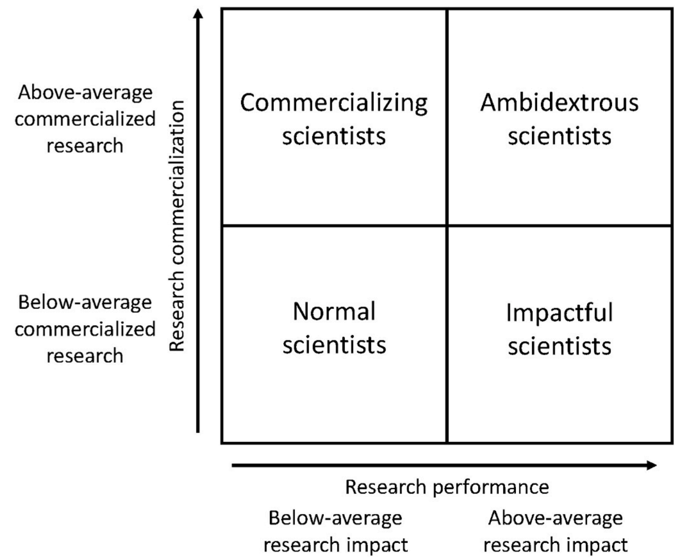

Fig. 1. Quadrant model considering research performance and research commercialization.

(Amara et al., 2019). Another reason could be that this group of scientists has little inclination to publish research results and peer recognition, which Roach and Sauermann (2010) calls a lower "taste for science". However, they are also referred to as normal scientists because they do not deviate from the usual behavior of merely generating research output. Their absence of commercializing behavior might be because of an unwillingness to act in such a way or the lack of research results that could be commercialized (Louis et al., 1989).

Impactful scientists: Among this group of scientists are those with a research performance characterized by an above-average impact but with no or underperforming commercialization of their research results. Scientists of this profile excel through scientific ideas that are relatively new and not yet supported by much previously created evidence, or their work influences the scientific community intellectually, which sparks further research and rewards their own research performance with high citations. They conduct their research due to their value of scientific inquiry and its continuous progress for its own sake (Dasgupta and David, 1994). Intrinsically, they derive satisfaction from the search for fundamental understanding and from solving concrete problems as part of a puzzle (Stokes, 1997; Lam, 2011). Extrinsic reasons for academics to aim for a research performance above the average scientist in their discipline are rooted in competition and the academic reward system (Stephan, 1996). The academic currency is reputation and peer recognition, which can be achieved through impactful publications and can enhance the chances of being awarded tenure (Lissoni et al., 2011). An increased research performance could be achieved without considering the commercial implementation of research results. One fear of scientists is that involvement in commercial activities will hamper their research performance and independence (Lee, 1996; Glaser and Bero, 2005; Baldini et al., 2007; Hossinger et al., 2020).

Commercializing scientists: Scientists in this profile exhibit research performance with a below-average impact, but in conjunction with their research, they also commercialize their results to an above-average extent. The reasons for academics to commercialize their research results are manifold. Besides the opportunity to build financial resources through commercialization (Fini et al., 2009; Hayter, 2011; Bodas Freitas and Nuvolari, 2012; Walter et al., 2018), for some it is an intrinsically motivated task of excitement to turn their research findings into a useful application (Lam, 2011). Academic career objectives are also defined or adjusted because high competition for tenured positions can lead to a closer approximation to commercially oriented activities. Evidence for this exists, especially for the creation of academic spin-offs,

[3] Ambidexterity research has already addressed the importance of considering the individual when looking at ambidextrous organizations (e.g. Keller and Weibler, 2015; Lam et al., 2019; Pertusa-Ortega et al., 2021). Bonesso et al. (2014) emphasize the need for such a focus because analyzing an organization's ambidexterity would implicitly assume the homogeneity of its employees.

which are often perceived as an alternative career path (Horta et al., 2016). Scientists who are involved in commercialization activities might have fewer resources available for increased research performance (Fabrizio and Di Minin, 2008; Buenstorf, 2009).[4]

Ambidextrous scientists: These scientists succeed in reconciling the two goals of an above-average research performance and research commercialization. In addition to their generation of impactful research, they also manage to exploit their research results commercially (van Looy et al., 2006; Buenstorf, 2009; Larsen, 2011). Such academics exhibit a hybrid role identity that allows them to follow the ideal of both an academic and a commercial persona (Jain et al., 2009). They figure out a way to conduct their different activities in a complementary way, allowing synergies to lead to positive outcomes (van Looy et al., 2004; Reymert and Thune, 2023). Fini et al. (2021) have shown that academic entrepreneurship stimulates scholars' attention to a broader and cross-disciplinary range of exploratory endeavors and thus increases the impact of their research.

2.3. *University scientists' forms of social capital*

Academics can utilize their social capital to achieve their multiple goals. Social capital refers to the set of resources one can access and mobilize for purposive actions by drawing on the social structure in which the individual is embedded (Portes, 1998; Lin, 2017). Social capital can be a supporting asset for both the conduct of impactful research and the process of commercializing research results. According to van Rijnsoever et al. (2008), a scientist's social capital can generate competitive advantages in individual career development in academia. However, to utilize such advantages, drawing upon the scientist's diverse networks is crucial. In the same vein, Hayter (2016a,b) shows that along the spin-off creation process of scientists, various networks are essential to connect to, while Karlsson and Wigren (2012) find a positive correlation between contacts to non-university actors and their propensity to found a firm. This positive correlation is also present for commercializing research results via patents and licenses (Kalar and Antoncic, 2016).

According to social capital theory, these social structures and networks can be distinguished into three forms of social capital: bonding, bridging, and linking social capital (Granovetter, 1973; Putnam, 2001; Szreter and Woolcock, 2004). They differ in terms of their network type, strength of ties, type of relationships, trust and benefits. *Bonding social capital* captures strong ties within a closed intra-community network, such as peers, with close social proximity and a common social identity (Coleman, 1988; Putnam, 2001). Such relationships are characterized by more informal collaborations with thick trust and long-term reciprocity, from which actors can benefit in terms of achieving common goals. *Bridging social capital* on the other hand captures weak ties established to external heterogeneous actors of extra-community networks across social distance with a different social identity (Granovetter, 1973; Burt, 2000; Putnam, 2001). These relationships reflect more formalized collaborations with thinner trust and reciprocity done to share resources and knowledge. *Linking social capital* is defined as "norms of respect and networks of trusting relationships between people who are interacting across explicit, formal or institutionalized power or authority gradients" (Szreter and Woolcock, 2004, p. 655). This means that this form of social capital describes neither the individual intra- nor extra-community connection but the institutionalized linking of one's community with other communities to enable interaction. It raises the consideration of ties to an institutional level (Stone and Hughes, 2002). It was introduced to social capital theory to underline the importance of formal institutions linking dissimilar groups of actors to leverage resources, ideas, and information beyond the community (Woolcock, 2001). These can be, for example, institutions that provide information and support to enable the goals of the intra-community (Cofré-Bravo et al., 2019). It is the relationship of intra-community actors to these institutions that have relative power over them and expect those actors to establish ties to distinct actors of extra-community networks.

In the following, the three introduced forms of social capital are discussed in the context of university scientists, and hypotheses are elaborated with regard to the extent in which they influence the profile affiliation of scientists and their multiple goal achievement (also see Table 1 for an overview and Fig. 2 for a graphic illustration).

2.3.1. *Scientists' bonding social capital*

Scientists at universities are predominantly embedded in the academic environment in which they bond with other scientific peers. They share the same norms and logic along the ethos of science, guaranteeing the freedom of research, an open science mentality, and the treatment of knowledge as a public good (Nelson, 1959a; Merton, 1973; Rosenberg, 1974; Baldini et al., 2007). Internalizing these norms and logic represents the pillars of their academic role identity (Jain et al., 2009). A common orientation towards publishing research is driven by the reward system under which they perform to gain peer recognition and reputation (Dasgupta and David, 1994). To achieve these goals, the dominating motivators for scientists are the quest for fundamental understanding and their enjoyment of puzzle-solving (Merton, 1968; Lam, 2011). Since they share the same goals, networking gives them a competitive advantage for several reasons (van Rijnsoever et al., 2008). First, they can combine complementary skills and thus take advantage of the division of labor and expand research output more time efficiently. Second, the mutual intellectual stimulation and discussions about their research can open up new research opportunities. Third, access to equipment and information can be achieved, facilitating the use of scarce resources. Such research-related benefits positively impact scientists' productivity and increase their chances of promotion along the academic career ladder (Lissoni et al., 2011). Bonding social capital of scientists induces trust in their relationships with peers and eases the exchange of information and resources between them. It can stimulate what Latour and Woolgar (1986) calls the "credibility cycle" of scientists. It is the circular process of research performance leading to rewards in terms of higher recognition, which eases the access to resources such as staff, equipment, and data and consequently lets the cycle continue with increased publications (Hessels et al., 2019). Evidence in the literature supports this effect. Besides the trend over the last decades showing a substantial increase in research collaborations in terms of co-authorship (Jones et al., 2008), the usage of scientists' bonding social capital positively impacts their research performance and, thus, their likelihood of being an impactful scientist as well as their likelihood of being an ambidextrous scientist (Lee and Bozeman, 2005). Considering the effects of scientists' bonding social capital on the goal of achieving noteworthy research performance mentioned above, the following hypotheses state.

H1a. A scientist's bonding social capital increases the likelihood to be an impactful scientist instead of being a normal scientist.

H1b. A scientist's bonding social capital increases the likelihood to be an ambidextrous scientist instead of being a normal scientist.

2.3.2. *Scientists' bridging social capital*

Scientists' bridging social capital in the context of the dichotomy between research performance and research commercialization refers to the ties to industrial actors. Industry actors operate under a different umbrella of norms and logic than academic scientists, characterized by market competition, rent-seeking under bureaucratic control, secrecy, and restrictions on disclosure (Hayter, 2011; Sauermann and Stephan, 2013). These norms fuel the treatment of knowledge as a private good for the goal of commercial exploitation (Levin et al., 1987; Dasgupta and David, 1994; Stephan, 1996). Thus, university scientists are confronted with

[4] Buenstorf (2009) discovered such a negative effect only for long-term influences of spin-offs but not for inventive activities.

Table 1
Forms of social capital (SC) and their application to university scientists multiple goals achievement.

	Bonding SC	Bridging SC	Linking SC
Network type	Intra-community	Extra-community	Links between intra- and extra-community
Ties	Actors with close social proximity and common social identity	Actors with social distance and different social identity	Institutionalized power or authority gradients
Strength of ties	Strong	Weak	Weak
Type of relationships	Informal collaboration with long-term reciprocity	Formalized collaboration with short-term reciprocity	Formalized collaboration with long-term reciprocity
Trust	Thick	Thin	Thick
Benefits	Common goal achievement	Sharing resources and knowledge	Institutionalized support for linking to external networks (resources and information)
University scientists	Strong ties to peers within the scientific community	Weak ties to industrial actors	Weak ties to industry due to enabling links via university
	Sharing academic identity (norms and logic along ethos of science)	Confronted with entrepreneurial identity (norms and logic of commercialization)	Institutionalization of commercialization behavior by entrepreneurial university
	Informal collaboration to gain competitive advantages	Formal collaboration to gain non-redundant knowledge and resources	Formal relationship to university as employer and its mission of research commercialization
	Common goals: research performance and peer recognition	Different goals: research publication vs. research commercialization	Institutionalized goal: research commercialization
Multiple goals	Research performance	Research commercialization	Research commercialization

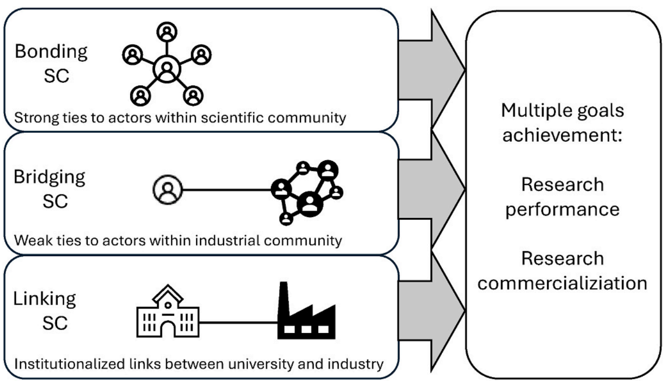

Fig. 2. University scientists forms of social capital (SC) influencing multiple goals achievement.

interactions with actors who have internalized an entrepreneurial role identity (Jain et al., 2009; Hayter et al., 2022). These differences in the norms and goals between scientists and industrial actors result in a thinner trust (Bruneel et al., 2010; Bellini et al., 2018). Even though scientists' bridging social capital is characterized by these mismatches, establishing ties to the industry brings some beneficial effects. It facilitates the flow of non-redundant information, increasing scientists' information diversity (Burt, 2004). It gives scientists commercial insights, creates visions for industrial applications, and changes their perspective to an industrial one (Dolmans et al., 2022). Having a network that includes industry members can help scientists overcome a lack of commercialization-specific human capital (Colyvas et al., 2002). Such ties to industrial actors enable scientists to acquire knowledge conversion capability (Sousa-Ginel et al., 2021), which they can use to turn their research results into commercial applications. Moreover, it can help them to adapt their academic role identity by incorporating entrepreneurial elements and, thus, achieve a hybrid role identity that combines academic and commercial norms and logic (Jain et al., 2009; Hayter et al., 2022). Evidence in the literature shows that it is more attractive for scientists who collaborate with industry to create a spin-off and that there is a higher probability they engage in such an activity (Gulbrandsen and Smeby, 2005; Fritsch and Krabel, 2012; Krabel and Mueller, 2009). Furthermore, scientists involved in research collaborations with industry are more likely to be engaged in patenting activities (Boardman and Ponomariov, 2009; Prodan and Drnovsek, 2010) and more likely to license inventions (Wu et al., 2015). Considering the effects of scientists' bridging social capital on the goal of achieving research commercialization mentioned above, the following hypotheses state.

H2a. A scientist's bridging social capital increases the likelihood to be a commercializing scientist instead of being a normal scientist.

H2b. A scientist's bridging social capital increases the likelihood to be an ambidextrous scientist instead of being a normal scientist.

2.3.3. Scientists' linking social capital

Scientists' linking social capital refers to the institutionalization of ties to the industry induced by the university with which they are affiliated. Thus, it encompasses the encouragement and support of commercialization-oriented behavior by formalizing it as an entrepreneurial university through established organizational structures and policies (Guerrero et al., 2016). In addition to the establishment of technology transfer offices for legal and technical support along the commercialization process (Bradley et al., 2013), this can also be achieved through the establishment of incubators (Kolympiris and Klein, 2017), the integration of commercialization-oriented criteria for promotion and tenure (Grimaldi et al., 2011), or through further educational programs for commercialization (Bolzani et al., 2021). The reciprocity of the relationship between the scientist and their university is characterized by the university's expectation to establish ties to distinct actors of extra-community networks in exchange for providing the scientist with resources to achieve their goals. Universities can function as boundary-spanning organizations activating relations between unrelated actors, namely scientists from academia and industrial actors, enabling non-redundant knowledge exchange (Burt, 2007; Comacchio et al., 2012). Scientists are influenced by their environment and the contextual setting in which they act. When scientists perceive their working environment as oriented towards research commercialization due to linkages with industry, their own behavior towards such activities is significantly influenced (Kalar and Antoncic, 2015). According to in-depth interviews in the UK, Ankrah et al. (2013) find that among the main motives for scientists to interact with the industry is the necessity to engage due to their university's strategic institutional policy. Universities aiming to link to the industry can be seen as brokers between scientists and industrial actors, which facilitates scientists' establishing ties to the industry. Consequently, scientists can access external knowledge and resources that positively influence their propensity to commercialize research results. Considering the effects of scientists' linking social capital on the goal of achieving research commercialization mentioned above, the following hypotheses state.

H3a. A scientist's linking social capital increases the likelihood to be a commercializing scientist instead of being a normal scientist.

H3b. A scientist's linking social capital increases the likelihood to be an ambidextrous scientist instead of being a normal scientist.

2.3.4. Negative effect of bonding social capital

The potential advantages of being embedded in a cohesive network characterized by similarity, social proximity, and the resulting thick trust cannot be denied. However, social capital literature also brings up concerns regarding the potential negative effects of bonding social capital (Portes, 1998). An overabundance of bonding social capital in the form of strong ties to actors who are alike, can cause a predominant inflow of redundant knowledge (ter Wal et al., 2016). A too-strong reliance on bonding social capital can lead to homophily (a strong bonding with similar actors), which limits a broad perspective and access to unknown information and knowledge (McPherson et al., 2001). This can lead to lock-ins and an increased risk of opportunistic behavior, ultimately harming the benefits of interactive learning in the network (Boschma, 2005). Since the professional network of scientists can be considered a homophilous one (Hayter, 2016b), it is reasonable to assume that the benefits of scientists' bonding social capital might become detrimental to their research performance.[5] Thus, the following hypotheses state.

H4a. There is an inverted U-shaped relationship between a scientist's bonding social capital and the likelihood to be an impactful scientist instead of being a normal scientist.

H4b. There is an inverted U-shaped relationship between a scientist's bonding social capital and the likelihood to be an ambidextrous scientist instead of being a normal scientist.

3. Data and method

3.1. Data

The data for the empirical investigation consists of primary and secondary data. Regarding the primary data, a novel online survey of academic staff at universities in the German Federal State of Thuringia was conducted. Thuringia is a suitable case for this study, as it adequately reflects the variety in the German research landscape. Four universities and six universities of applied sciences are located within the state. Out of the four universities, one is a technical university and one is affiliated with a university hospital. Among the six universities of applied sciences there is also the rare case of a music college. After the collection of publicly available contact information and characteristics of the scientists from their universities' web pages, 6301 scientists had been identified to whom an invitation for the web-based survey was sent in December 2019 and January 2020.[6] 1072 scientists accepted the invitation and participated in the survey, resulting in a response rate of 17%. Of these responses, 15 observations had to be discarded due to missing data. Thus, the working sample for the empirical analysis consists of 1057 observations. The differences between this working sample of respondents and the initial population are predominantly marginal, and I consider a non-response bias unlikely with a small tendency towards over- and under-representation of some disciplines.[7] The comparison of the working sample with the overall population of scientists at universities in Germany (Statistisches Bundesamt, 2020) reveals representativeness of the sample in terms of academic rank and gender (Table S2 in the Online Appendix).

The online survey consisted of questions on the scientists' commercialization activities: selling and licensing of intellectual property (IP) and creating an academic spin-off. In addition, their collaboration activities with industry actors were asked about. Furthermore, the survey collected information on scientists' characteristics regarding their socio-demographic situation, research activity, and working conditions. The items had been discussed with colleagues specialized in research commercialization and practitioners from technology transfer offices. Subsequently, a pre-test of the survey was conducted in a comparable German state with a random sample of scientists, as suggested by Sue and Ritter (2007).[8]

In addition to the survey data, secondary sources provide further information about individual scientists and universities. First, I collected data on the respondents' publication records from Web of Science (WoS) and Scopus.[9] Second, I collected data on the third-party funding of each university, which is provided by the German Ministry of Education and Research.

3.2. Empirical specification

To answer the research question and test the hypotheses I estimate a multinomial logistic regression that relates the probability of scientist i belonging to the profile j to the measures for the scientist's forms of social capital and to a set of control variables. The equation is defined as:

$$\Pr(y_i = j|x_i) = \frac{\exp(x_i\beta_i)}{\sum_{j=1}^{M}\exp(x_i\beta_i)} \quad (1)$$

where $j = 1, \ldots 4$ captures the profiles (Normal scientist, Impactful scientist, Commercializing scientist and Ambidextrous scientist). $\Pr(y_i = j|x_i)$ is the probability that scientist i is in the profile j, given x_i, whereby x_i is a vector of characteristics of individual i capturing the forms of social capital as well as control variables, and β_j is the vector of coefficients pertaining to scientist profile j. The forms of social capital are assumed to impact $\Pr(y_i = j|x_i)$ by either facilitating research performance, research ambidexterity or both.

3.3. Measures

3.3.1. Operationalization of the dependent variable

To contrast the two goals scientists are required to achieve, research performance and research commercialization were independently quantified. As Lin and Bozeman (2006) have noted, there is no standardized way of measuring research performance. The most conventional way to quantify scientists' research performance is by the impact of their published papers in terms of citations (Ding and Choi, 2011; D'Este et al., 2012, 2019). In this study, I quantified research performance by the research impact index provided by Olmos-Peñuela et al. (2014). The index measures the impact of each individual scientist by

[5] No hypotheses are derived that address a possible negative effect of bridging and linking social capital, since social capital theory does not discuss such a relationship in these two forms.

[6] Originally, the survey was extended to research institutes in Thuringia with 1484 additional survey invitations resulting in 337 additional responses. They are not considered in this study since it focuses on universities only. Published studies that also use the survey data are as follows: Cantner et al. (2024a, 2024b) and Huegel et al. (2023).

[7] I compared the characteristics academic rank, gender, and discipline between the overall population and the working sample (Armstrong and Overton, 1977) in Table S1 in the Online Appendix. There are some statistically significant differences concerning the disciplines. There is, for example, an under-representation of scientists from medicine in the respondents. This might be because the initial data collection included many medical doctors with an affiliation with the university hospital that are not involved in research anymore.

[8] Surveys are generally prone to various forms of bias, which were taken into account when developing the survey items so that their occurrence was prevented as far as possible (e.g. social desirability bias or question order bias). To ensure a high validity of the data, respondents were always reminded of the surveyed period of five years, and various forms of industrial relations were clearly delineated in their descriptions.

[9] The primary source for publication data is WoS. If there was no publication record in WoS for a respondent, I used Scopus, which has a larger coverage for some disciplines esp. for social sciences and humanities, (Norris and Oppenheim, 2007; Martín-Martín et al., 2021). If, again, there were no publications listed in Scopus, I assumed zero publications, which is especially plausible for PhD researchers at the beginning of their academic careers.

the average number of citations per year and publication.[10] The exposure of a scientist's research performance is captured by a five-year time-span (2015–2019) instead of a cumulative measure referring to research performance along the scientist's career. This period was chosen to contrast research performance with research commercialization within the same time. Consequently, for each publication, I divided the number of citations by the number of years since publication until 2019, taking into account only those publications that fall within the selected time period. The formula is defined as follows:

Research impact index

$$= \frac{\sum_{i=1}^{N}(\text{number of citations}_i)/([2020 - \text{publication year}]_i)}{\text{number of publications } (N)} \quad (2)$$

In order to avoid distortions in performance rankings, Abramo et al. (2008) recommend to compare only scientists within the same discipline since publication and citation behavior differs substantially between disciplines. Thus, scientists are assigned to seven broader disciplines: *computer science and mathematics*, *engineering*, *humanities*, *life sciences*, *medicine*, *physics and chemistry* and *social sciences*.[11] For each discipline I calculated the average research impact index, reflecting the threshold of the dichotomous variable distinguishing between out- and under-performing scientists.

The prevalence of scientists' research commercialization was identified by the combination of two survey items. Survey participants were asked to indicate (1) how many spin-offs they created and (2) how many ideas or inventions they sold or licensed to a company (capturing IP) between 2015 and 2019. Based on their responses, I created a dichotomous variable. If they indicated a spin-off creation, a sold or licensed IP, or both, the variable turns 1 and 0 otherwise (Ambos et al., 2008).[12]

The four configurations that correspond to the four scientist profiles were outlined by combining the two dichotomous variables for goal achievement of research performance and research commercialization in the following manner.

- Normal scientists: below-average research performance with no commercialized research results;
- Impactful scientists: above-average research performance with no commercialized research results;
- Commercializing scientists: below-average research performance with commercialized research results;
- Ambidextrous scientists: above-average research performance with commercialized research results.

3.3.2. Operationalization of the explanatory variables

To understand the impact of social capital on the probability of a scientist to belong to one of the four profiles, I used one proxy for each of the forms of bonding, bridging, and linking social capital. I operationalized the number of *co-authors per publication* to capture bonding social capital. I considered the number of unique co-authors (between 2015 and 2019) to exclude recurring co-authorships and divided it by the number of publications in the considered time period to use a measure that is sensitive to the different practices of co-authorship among disciplines (Wuchty et al., 2007; Youtie and Bozeman, 2014). This is to map the ties to actors with similar social identities, norms, and common goal pursuits, namely, generating impactful research output. Drawing on the number of unique co-authors a scientist has published with is a general measure for their academic network (Ding and Choi, 2011) and, thus, a suitable proxy for the degree of their bonding social capital. The variable is log-transformed to account for its right-skewed distribution. It enters the estimation as a linear term and a quadratic term. The latter is used to identify the assumed inverted U-shaped relationship discussed in 2.3.4.

Bridging social capital is proxied by the frequency of participation in *S–I collaborations* during the considered time span. It is based on a survey item in which respondents indicated how often they were involved in the "realization or participation in a research cooperation with company participation" and encompasses both funded research projects with company participation and contract research. The variable is also log-transformed because of right-skewedness and can be employed to capture the scientist's experience and knowledge exchange with industry (D`Este et al., 2012). It reflects the scientists' weak ties in the course of bridging social capital because during an S–I collaboration, the exchange with the company's employees is project-related and not related to the joint pursuit of academic goals such as impactful research generation.

For linking social capital, I obtained data on the universities' third-party funding structures. The share of *industry funding* in total third-party funding is calculated and reflects the institutional environment of an entrepreneurial university linked to industry (Etzkowitz, 1998), which enables scientists' interactions with industry actors (Boardman, 2009). I used the share of third-party funding from industry as a proxy for how strongly scientists' universities link to the industrial external network relative to other external sources.

3.3.3. Control variables

In addition to the measures for social capital, several control variables enter the model that can influence the probability of scientists belonging to one of the profiles. First, to control for scientists' orientations towards *applied research*, following Amara et al. (2019), they were asked to "assess the extent to which [… their] research is targeted towards practical application". The variables were assessed on a 4-point Likert scale, ranging from "not at all" to "a lot". Controlling for applied research is necessary because scientists with a stronger orientation towards applied research are more likely to produce industrial applications (Calderini et al., 2007), which should be a supportive factor for research ambidexterity. Second, in addition to research and commercialization, most university scientists also have teaching as a third pillar to serve, which in turn can affect individual resource availability for the other two goals (Landry et al., 2010; Reymert and Thune, 2023). Therefore, to control for *teaching workload*, respondents indicated what percentage of their working time is devoted to teaching activities. Third, I control for differences in *academic rank* by a categorial variable distinguishing between professors, postdoctoral scientists and scientists of other rank in the science system such as PhD students and technical personnel (Perkmann et al., 2021).[13] Fourth, to take into account the strong gender gap identified in the literature regarding research performance (see, e.g. Stack, 2004; Mayer and Rathmann, 2018) and research commercialization (see, e.g. Tartari and Salter, 2015; Abreu and Grinevich, 2017), I control for scientists' gender and distinguish between *female* and others. While differences in research disciplines are already accounted for in the distinction along the quadrant between out- and under-performing scientists, there are also differences in terms of their propensity to commercialize research results (see, e.g. Abreu and Grinevich, 2013; Perkmann et al., 2011). There are some disciplines facing higher tensions with regard to the fulfilment of research

[10] In doing so, I considered published articles, proceedings and conference papers, as well as books and book chapters, in order to take into account the different publication patterns of all disciplines (Abramo et al., 2008).

[11] The assignment to one of the seven disciplines was based on the information on each respondent's university website in order to determine their area of research (Affiliation to which department, chair, or research group). For this process, I used the subject classification system of the German Research Foundation (DFG), which assigns subjects to corresponding subject areas and scientific fields.

[12] Determining the threshold using the average of commercialized research results would result in the same split, as the average number of research commercialization by a scientist is 0.24.

[13] I treat junior professors equally to full professors.

commercialization (Philpott et al., 2011; Kalar and Antoncic, 2015). Thus, the same seven broader *disciplines*, previously used for the disciplinary average of research impact, are consulted to take these differences into account. Finally, a dummy variable called *university of applied sciences* accounts for whether the university to which a scientist belongs to is of such a type or not. An overview of the construction of each variable is presented in Table 5 in the Appendix.

4. Results

4.1. Descriptive results

An overview of the shares of scientists who out-perform, underperform, commercialize, or do not commercialize within their discipline is provided in Table 2. It shows how many scientists per discipline are represented in the sample, the discipline's specific threshold distinguishing between below and above-average research performance and the prevalence of commercialized research results within that discipline. The largest group are scientists from the social sciences, followed by engineers, while those from the life sciences are the least frequently observed. The heterogeneous citation patterns among disciplines become apparent when examining the average number of citations per year and publication for each discipline. On average, scientists in life sciences, medicine, physics, and chemistry receive more than two citations per year and publication, while the value is smaller than one for the humanities and social sciences. Considering the distinction regarding research performance, overall, 31.6% (334 of 1057 observations) are above-average performing scientists, with those from physics and chemistry showing the greatest share among their disciplinary peers, followed by scientists in life sciences, computer science, and mathematics. Turning to research commercialization, only 10.4% of all scientists in the sample have commercialized research results in the considered five-year time span. The disciplines with the highest share of scientists with commercialized research among their disciplinary peers are computer science and mathematics, physics, and chemistry, followed by scientists in engineering. Not surprisingly, scientists in the social sciences and humanities have a relatively low share of scientists with commercialized research results among their disciplinary peers. The share of above-average performing scientists in life sciences is relatively high but, surprisingly, they yield the lowest share of scientists who commercialize results.

The distribution of scientists in the sample across the four quadrants corresponding to the four profiles of the dependent variable is shown in ascending order in Table 3. The descriptive statistics of the complete sample can be found in Table 6 in the Appendix. With 4.16% (44 of 1057 observations) ambidextrous scientists, simultaneously outperforming in research and commercializing their results, constitute the smallest group. They are followed by commercializing scientists with a below-average research performance but commercialized research results with 6.24% (66 of 1057 observations) and impactful scientists with an above-average research performance but no commercialization to be reported with 27.44% (290 of 1057). The largest group with 62.16% (657 of 1057 observations) are the normal scientists showing a below-average research performance and no commercialized research results. When looking at the mean values of the measures for the different forms of scientists' social capital, one can already deduce tendencies with regards to their impact on profile affiliation. On average an ambidextrous scientist as well as an impactful scientist exhibits a greater bonding social capital in terms of unique co-authors per publication compared to the average commercializing or normal scientist. In a similar vein, regarding bridging social capital, an average ambidextrous or commercializing scientist has been involved in more S–I collaborations compared to the other two profiles. Likewise, linking social capital, captured by industry funding, is also on average more pronounced for those profiles. Considering the control variables, the scientist profiles with the highest orientation towards applied research are those with commercialized research results. Ambidextrous scientists, on average, have a lower teaching workload than scientists of the remaining profiles. Furthermore, one can elicit that in terms of academic rank, it is postdocs who make up the largest share of ambidextrous and impactful scientists, while scientists who do not yet have a PhD are most strongly represented among commercial and normal scientists. 68% of the ambidextrous scientists are from the disciplines of computer science and mathematics, engineering, physics, and chemistry, while no scientist in the life Sciences can be found in this profile.

4.2. Regression results

The results of the empirical analysis are presented in Table 4. For the multinomial logit estimation the profile of normal scientists is chosen to be the reference category. The estimates of the remaining profiles are in columns 1–3. First, turning the attention to the impact of scientists' bonding social capital on their profile affiliation, the results show a positive and significant influence of scientists' bonding social capital, in terms of the number of their unique *co-authors per publication*, on the probability to be in the profile of an impactful scientist instead of a normal scientist. This result supports hypothesis 1a stating a positive correlation between scientists' bonding social capital and the probability of being an impactful scientist compared to the baseline profile. The same relationship can be elicited for ambidextrous scientists. Bonding social capital also significantly increases the likelihood to be a scientist of this profile instead of being a normal scientist. This gives support for hypothesis 1b.

Regarding the impact of scientists' bridging social capital on their profile affiliation, the coefficient for *S–I collaboration* in column 2, which captures the group of commercializing scientists, is positive and statistically significant. This provides support in favor of hypothesis 2a, which assumes a positive impact of scientists' bridging social capital on the probability of being a commercializing scientist compared to the baseline profile. The third column represents ambidextrous scientists and shows a positive and significant correlation of scientists' bridging social capital to the likelihood of belonging to this profile instead of being a normal scientist, supporting hypothesis 2b.

With regard to linking social capital and its influence on being a commercializing scientist, column 2 shows no significant correlation between *industry funding*, the proxy for this form of social capital, and the dependent variable. This rejects hypothesis 3a, which states that scientists' linking social capital has a positive impact on their probability of becoming commercializing scientists. Linking social capital positively impacts the likelihood to be an ambidextrous scientist instead of being a normal scientist. This is apparent due to the statistically significant coefficient of industry funding in column 3 supporting hypothesis 3b.

Finally, the coefficient of the quadratic term for bonding social capital should provide information on whether an inverted U-shaped relationship prevails and whether an excess of this form of social capital can turn into a negative effect. Indeed, strong bonding social capital can negatively impact research performance and reduce the likelihood of being included in the impactful scientist's profile. This is evident from the negative and statistically significant coefficient of *squared co-authors per publication* and, thus, supports hypothesis 4a. According to the estimated curve, the number of co-authors per publication that would result in the highest probability of being an impactful scientist is 24.67.[14] Thus, in the range of 0–24, increasing the number of unique co-authors per paper increases the probability of being an impactful scientist, but beyond that threshold, higher bonding social capital is associated with a

[14] This is the anti-logarithm of x satisfying the first order condition of the maximization problem for being an impactful scientist, i.e., $x = \beta_{[\text{coauthors}]} / \left[-2 * \beta_{[\text{coauthors}^2]} \right]$ This turning point falls within the data range (0–642.67).

Table 2
Research performance and research commercialization by discipline.

	Obs	Performance					Commercialization			
		average	below	%	above	%	no	%	yes	%
Computer Science and Mathematics	144	1.07	91	63.20	53	36.80	120	83.30	24	16.70
Engineering	173	0.65	125	72.30	48	27.70	150	86.70	23	13.30
Humanities	102	0.17	88	86.30	14	13.70	96	94.10	6	5.90
Life Sciences	87	2.83	54	62.10	33	37.90	85	97.70	2	2.30
Medicine	129	2.72	83	64.30	46	35.70	117	90.70	12	9.30
Physics and Chemistry	150	2.97	91	60.70	59	39.30	125	83.30	25	16.70
Social Sciences	272	0.75	191	70.20	81	29.80	254	93.40	18	6.60
All disciplines	1.057		723	68.4	334	31.6	947	89.6	110	10.4

Table 3
Descriptive statistics for the four profiles.

	Ambidextrous				Commercializing				Impactful				Normal			
	mean	sd	min	max	mean	sd	min	max	mean	sd	min	max	mean	sd	min	max
Co-authors per publication (log)	1.83	0.60	0.70	3.50	0.45	0.76	0	3	1.76	0.73	0.20	6.50	0.52	0.83	0	4.20
S–I collaborations (log)	1.03	0.79	0	2.80	0.93	0.85	0	2.80	0.40	0.62	0	2.80	0.28	0.52	0	2.80
Industry funding	0.19	0.14	0	1	0.15	0.13	0	1	0.15	0.08	0	1	0.14	0.10	0	1
Applied research	3.14	0.73	1	4	3.17	0.78	1	4	2.56	0.72	1	4	2.73	0.88	1	4
Teaching workload	16.86	13.44	0	70	28.45	22.77	0	100	24.59	18.26	0	90	27.45	24.17	0	100
Professor	0.30	0.46	0	1	0.32	0.47	0	1	0.27	0.44	0	1	0.17	0.37	0	1
Postdoc	0.39	0.49	0	1	0.20	0.40	0	1	0.41	0.49	0	1	0.21	0.41	0	1
Other	0.32	0.47	0	1	0.48	0.50	0	1	0.32	0.47	0	1	0.63	0.48	0	1
Female (=1)	0.23	0.42	0	1	0.32	0.47	0	1	0.33	0.47	0	1	0.41	0.49	0	1
Discipline: Computer Science and Mathematics	0.20	0.41	0	1	0.23	0.42	0	1	0.15	0.36	0	1	0.12	0.32	0	1
Discipline: Engineering	0.25	0.44	0	1	0.18	0.39	0	1	0.13	0.33	0	1	0.17	0.38	0	1
Discipline: Humanities	0.07	0.25	0	1	0.05	0.21	0	1	0.04	0.19	0	1	0.13	0.34	0	1
Discipline: Life Sciences	0	0	0	0	0.03	0.17	0	1	0.11	0.32	0	1	0.08	0.27	0	1
Discipline: Medicine	0.16	0.37	0	1	0.08	0.27	0	1	0.13	0.34	0	1	0.12	0.32	0	1
Discipline: Physics and Chemistry	0.23	0.42	0	1	0.23	0.42	0	1	0.17	0.38	0	1	0.12	0.32	0	1
Discipline: Social Sciences	0.09	0.29	0	1	0.21	0.41	0	1	0.27	0.44	0	1	0.27	0.44	0	1
University of Applied Sciences (=1)	0.25	0.44	0	1	0.29	0.46	0	1	0.16	0.37	0	1	0.29	0.45	0	1
N	44				66				290				657			
Share	4.16%				6.24%				27.44%				62.16%			

decreasing probability. In the same vein, this coefficient is also negatively significant in the third column. It reveals an inverted U-shaped relationship between bonding social capital and the likelihood of being an ambidextrous scientist, with the turning point at 14.82 co-authors. This result provides support for hypothesis 4b.

In addition, the control variables reveal some further notable results. A research orientation towards applied research increases the probability of being a commercializing scientist but significantly decreases the probability of being an impactful scientist. Teaching workload has a significantly negative impact on the chances of being an ambidextrous scientist. Being a professor or a postdoc significantly increases the probability of belonging to one of the three other profiles instead of being a normal scientist. The adjusted R^2 is at 0.3561 and indicates a good model fit (McFadden, 1974).

4.3. Robustness tests

I conducted two additional multinomial regressions to test for the robustness of the results. First, a subsample analysis is performed, which excludes scientists from the humanities and social sciences since they can have substantially different preconditions for research commercialization. Second, a stricter threshold for the classification of out- and under-performing scientists is used to check the robustness of the results regarding the determination of this threshold.

Concerning the first robustness test, scientists from the social sciences and humanities are excluded, leaving a subsample of 683 observations (see Table 7 in the Appendix). The reason is to adjust for potential differences in the industrial applicability of knowledge within the academic disciplines. Scientists in these disciplines predominantly engage in activities with no direct commercial output (Olmos-Peñuela et al., 2014). The ensuing results are very similar to those of the main model, with no changes in the significance levels of the explanatory variables.

In the second robustness test, the upper quartile of all scientists' citations per year and publication in the respective discipline is used as the threshold to determine whether a scientist is an out- or under-performer (see Table 9 in the Appendix). It is a stricter threshold compared to the mean taken for constructing the dependent variable in the main model. It leads to a new distribution of scientists' profile affiliations with 2.93% being ambidextrous scientists, 7.47% as commercializing scientists, 21.38% belonging to the profile of an impactful scientist and 68.21% normal scientists (see Table 8). The results are again very similar to the main model, except for *industry* funding, which significantly facilitates being a commercializing scientist — a relationship that could not be retrieved from the main model.

5. Discussion and conclusion

Scientists at universities are increasingly confronted with the necessity to achieve multiple goals at the same time. In addition to producing impactful research as the driver of their own academic career, they are also expected to commercialize their research results. University scientists are heterogeneous, which is obvious when it comes to meeting these goals. On the one hand, there is the desire to be a prolific scientist and on the other hand, there is the commercial exploitation of research results. While scholars so far have characterized scientists by their research orientation (Stokes, 1997), their orientation towards university-industry connections (Lam, 2010) or their collaboration

Table 4
Multinomial logistic regression on scientist profiles.

	Categories of dependent variable:		
	Impactful	Commercializing	Ambidextrous
Bonding Social Capital			
Co-authors per publication (log)	3.834***	−0.562*	5.451***
	(0.621)	(0.326)	(1.028)
Co-authors per publication $(\log)^2$	−0.598***	0.063	−1.011***
	(0.216)	(0.067)	(0.275)
Bridging Social Capital			
S–I collaborations (log)	0.148	1.222***	0.969***
	(0.188)	(0.201)	(0.280)
Linking Social Capital			
Industry funding	0.881	1.556	5.860***
	(0.997)	(1.082)	(1.547)
Control variables			
Applied research	−0.231*	0.365*	0.413
	(0.134)	(0.187)	(0.322)
Teaching workload	−0.002	0.004	−0.037**
	(0.006)	(0.007)	(0.018)
Professor	1.163***	0.785**	1.602**
	(0.269)	(0.387)	(0.727)
Postdoc	0.930***	0.227	1.064**
	(0.239)	(0.422)	(0.513)
Female	−0.281	−0.004	−0.615
	(0.209)	(0.308)	(0.465)
Discipline: Engineering	0.404	−0.851	0.514
	(0.443)	(0.530)	(0.700)
Discipline: Humanities	0.426	−1.036	2.135**
	(0.519)	(0.724)	(0.951)
Discipline: Life Sciences	−0.837*	−1.037	−15.476***
	(0.459)	(0.896)	(0.728)
Discipline: Medicine	−1.830***	−0.689	−1.987***
	(0.424)	(0.674)	(0.732)
Discipline: Physics and Chemistry	−0.837**	0.502	−0.195
	(0.366)	(0.467)	(0.580)
Discipline: Social Sciences	0.793**	−0.640	0.147
	(0.369)	(0.457)	(0.736)
Univ. of Applied Sciences (=1)	−0.170	−0.212	0.367
	(0.324)	(0.424)	(0.561)
Constant	−3.934***	−3.907***	−10.006***
	(0.670)	(0.708)	(1.577)
N	1057		
Wald Chi^2	1363.46		
Adj. R^2	0.3561		

Robust standard errors in parentheses.
***p<0.01, **p<0.05, *p<0.1.
Reference category for *Discipline*: Computer Science and Mathematics.
Reference category for *Academic rank*: Other (including PhD students and technical personnel).

strategies (Bozeman and Corley, 2004), this study conceptualizes scientist profiles by contrasting their goal achievement regarding research performance and research commercialization. I derived four profiles based on scientists' citations per year and publication and the prevalence of commercialized research results: normal scientists with a below-average research performance and no commercialized research results, impactful scientists with an above-average research performance but without commercialized results, commercializing scientists with a below-average research performance but with commercialized results, and ambidextrous scientists with both an above-average research performance and commercialized results. In addition, I applied social capital theory to explain which form of social capital positively influences the achievement of these goals and consequently affects scientists' profile affiliation. Three forms of social capital are defined (Granovetter, 1973; Putnam, 2001; Szreter and Woolcock, 2004) and applied to the university context: bonding social capital as the ties to other scientists, bridging social capital as the ties to the industry, and linking social capital as the boundary-spanning activity of the scientists' universities.

Based on this conceptualization of scientist profiles and the theoretical background of social capital, I derived hypotheses to explain how different forms of social capital affect scientists' achievement of multiple goals. The assumption is that scientists' bonding social capital positively influences their research performance, which increases their likelihood of being an impactful or ambidextrous scientist. In addition, scientists' bridging and linking social capital should have a positive impact on their research commercialization and, thus, increase the probability of belonging to the profile of commercializing or ambidextrous scientists. Furthermore, I examined whether the potential negative effect of excessive bonding social capital, mentioned in social capital theory, can be identified in the context of an inverted U-shaped relationship between this form of scientists' social capital and their profile affiliation. To test these hypotheses, a novel representative survey of scientists in the German state of Thuringia was conducted and combined with data on respondents' publication records and on the universities' funding structures. I applied a multinomial logistic regression model to estimate the effect of social capital forms on scientists' profiles.

The descriptive results show a great variety in research performance and commercialization behavior between disciplines. Scientists from computer science, mathematics, engineering, physics, and chemistry excel through a relatively high average research performance and a high share of commercializing scientists. Across all disciplines, 10.4% report commercialized research results, a ratio in line with previous findings in this field (Landry et al., 2010; Abreu and Grinevich, 2013; Llopis et al., 2018; D'Este et al., 2019). The same applies to the share of those scientists who perform outstandingly (31.6%) measured by the average citations per year and publication (Olmos-Peñuela et al., 2014). Regarding scientists' profiles, only 4.16% of the scientists can be categorized into the profile of ambidextrous scientists achieving both goals. Slightly more, 6.24%, are commercializing scientists, while 27.44% are impactful scientists with no commercialization. The remaining normal scientists make up 62.16%.

The regression results support the hypotheses of a positive relationship between scientists' bonding social capital and the probability of being an above-average research performer in the profile of an impactful scientist as well as an ambidextrous scientist. Accessing a more extensive network of peers who share the same academic goals provides competitive advantages in the competition for publications and citations (van Rijnsoever et al., 2008; Hessels et al., 2019). The results indicate support for the hypothesized positive association between bridging social capital and commercializing as well as ambidextrous scientists. This relationship points to the importance of contacts to the industrial sector for successfully converting generated knowledge into commercializable products and services and for acquiring the necessary information and skills along this process (Sousa-Ginel et al., 2021; Cantner et al., 2024a; Dolmans et al., 2022). This correlation only applies in part when considering linking social capital. It does not affect the affiliation to the profile of commercializing scientists, but it does affect affiliation to the ambidextrous scientist profile. For the latter, the university acts as a boundary spanner between academia and industry (Slavtchev and Göktepe-Hultén, 2016; Chau et al., 2017). These results emphasize the advantage of access to different networks in the achievement of multiple goals such as outstanding research performances and research commercialization (van Rijnsoever et al., 2008; Hayter, 2016b). However, an inverted U-shaped relationship between the number of co-authors per publication and the profiles of impactful and ambidextrous scientists is identified, indicating a disadvantageous effect for excessive bonding of scientists to their scientific peers. The finding of this relationship is in line with previous social capital research and highlights the potential overabundance of redundant information within a cohesive network and a declining value of bonding social capital as a resource for impactful research (Portes, 1998; Boschma, 2005; ter Wal et al., 2016).

Besides the main findings supporting the hypotheses, the results also provide additional interesting insights considering the control variables. Scientists with a stronger orientation towards applied research are more likely to be commercializing scientists, which is in line with their higher propensity to generate knowledge relevant for industrial application (Calderini et al., 2007; Amara et al., 2019). It turns out that professorship is a relatively good predictor for being in one of the three profiles that deviates from the norm of normal scientists. A high teaching workload, however, prevents multiple goal achievement. The results are considerably robust with regard to a subsample analysis excluding scientists from the social sciences and humanities as well as when adhering to a stricter threshold for the classification into out- and under-performers.

This study contributes to the understanding of how scientists achieve multiple and tension-filled goals by contrasting scientists' research performance with research commercialization. Therefore, a typology of scientists is conceptualized and characterized through achieving these goals. While existing research has so far focused on one of these goals (e.g. Chang et al., 2016; Broström, 2019), this study considers the achievement of both goals at the same time and sheds light on this conflicting challenge for scientists. Additionally, the study provides first insights into the importance of different forms of social capital in the university context by defining scientists bonding, bridging, and linking social capital and how these forms of social capital determine research performances and research commercialization (Granovetter, 1973; Putnam, 2001; Szreter and Woolcock, 2004). The results regarding the impact of bonding social capital underline the positive impact of ties to scientific peers but also reveal that this relationship can have a disadvantageous effect on being an impactful and ambidextrous scientist (van Rijnsoever et al., 2008; Banal-Estañol et al., 2015). The identified relationship between bridging and linking social capital with scientists' goals contributes to the growing literature highlighting the advantages of hybridization of the academic and commercial system (Owen-Smith, 2003). According to this stream of literature, universities are well advised to create hybrid spaces where multiple logics can prevail so that academic and commercial logic can co-exist (Sauermann and Stephan, 2013; Perkmann et al., 2019; Cantner et al., 2024a). Such spaces, in turn, allow the individual scientist to adopt a hybrid role identity and to be both an academic and a commercially oriented actor simultaneously (Jain et al., 2009; Lam, 2010, 2011). This study extends this avenue of research, suggesting a hybrid social capital of scientists consisting of different forms that can serve to achieve multiple goals.

The findings can also be used to derive implications for policymakers and university management regarding the promotion of multiple goal achievement by scientists. First, since connections between actors within science can facilitate their research performance, policymakers and universities should try to foster collaborative research through incentives such as funding programs for joint research projects and financial support for networking activities, such as conferences. Second, ties between scientists and industry actors should be leveraged to increase scientists' bridging social capital and, thus, increase their propensity to commercialize research results. For this purpose, policymakers can also set up support programs that promote joint projects with industry actors more effectively. University managers could foster the visibility of outstanding scientists to draw the attention of interested companies to the scientists' competencies and to reward collaborations between them. Universities should create various access points to the industry to link the academic environment of their employees with the commercial sector.

The study is subject to several limitations that can be addressed in future work. First, measuring the various forms of scientists' social capital might not capture all facets of contacts and connections (Kawachi et al., 2004). An extension of proxies for bonding social capital could also be relationships with former colleagues or acquaintances through research stays. At the same time, informal contacts with industry through meetings at university and non-university events could enrich scientists' bridging social capital. Furthermore, the proxy used for scientists' bridging social capital does not take into account the size of the participating companies or the number of employees from that company involved in the collaboration, which future studies of this form of social capital and its heterogeneous magnitude among scientists could attempt to capture. Second, another goal is of high relevance among university scientists, and that is the production of human capital through teaching activities (Fromhold-Eisebith and Werker, 2013). Quantifying teaching output at the individual level may be a difficult task, but future typologies of scientists along their multiple goal achievement should take such activities into account (Reymert and Thune, 2023). Third, no qualitative measurement of the ties among the different forms of social capital is made. The scientific quality of the co-authors or the commercial success of the firms to which the scientist is related could have a different impact on the goals pursued by the scientist, which could be accounted for in future analyses of this kind. Fourthly, although differences between the disciplines were taken into account when determining research performance (discipline-specific averaging when identifying the threshold and inclusion not only of journal articles but also of books and book chapters), the use of publication databases can lead to disciplinary differences in the coverage of the publication record and underestimate the performance of individual scientists (Norris and Oppenheim, 2007; Mongeon and Paul-Hus, 2016). Efforts are needed here to build up complete databases in the science of science (Fortunato et al., 2018).

Besides these limitations, further research on scientist profiles should consider additional outreach activities unrelated to commercialization in the industrial context, such as the societal engagement of scientists (Bornmann, 2013; Benneworth and Cunha, 2015; Fini et al., 2018) for which bridging social capital, captured by contacts to society or involvement in citizen sciences, might be of interest (Franzoni and Sauermann, 2014). In addition, quantitative and qualitative network analyses offer a wide range of research possibilities through which the network structures of the different forms of scientists' social capital can be further illuminated.

CRediT authorship contribution statement

Matthias Huegel: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.technovation.2024.103065.

Appendix

Variable construction.

Table 5
List of variables and their construction.

Variable	Construction	Data type
Dependent variable		
Scientist profiles	Quadrant model contrasting 1: Research performance & 2: Research commercialization 1: Research impact index: Average number of citations per year and publication (Olmos-Peñuela et al., 2014) (Data collected from Web of Science and Scopus) 2: Commercialization of research results (yes/no) (Survey items: *Selling or licensing of an idea or invention* e.g. *selling a patent to a company & Completed foundation of a firm, i.e. the launch of business activities.*)	Categorical
Bonding social capital		
Co-authors per publication	Number of unique co-authors per publication	Numerical
Bridging social capital		
S–I collaborations	Survey item: *Realisation or participation in a research cooperation with company participation.* (Frequency of involvement in the period between 2015 and 2019)	Numerical
Linking social capital		
Industry funding	University's share of third-party funding from industry	Numerical
Control variables		
Applied research	Survey item: *Please assess the extent to which your research is targeted towards practical application.* (4-point Likert-scale: "Not at all" to "To a large extent")	Numerical
Teaching workload	Survey item: *How was your scientific working time distributed on average during the last 5 years over the following activities?* (in %; for the activity "Teaching")	Numerical
Academic rank	Survey item: *Which of the following options describes your current position best?* (Professor, Postdoc, PhD student, Technical personnel)	Categorical
Female (=1)	Survey item: *Please indicate your gender.*	Binary
Discipline	Assignment to one of seven disciplines based on the information on each respondent's university website in order to determine area of research (Affiliation to which department, chair or research group). For this process, the subject classification system of the German Research Foundation (DFG) was used, which assigns subjects to corresponding subject areas and scientific fields.	Categorical
University of Applied Sciences (=1)	Distinction of organizations between 1 = University of Applied Sciences & 0 = Traditional University	Binary

Table 6
Descriptive statistics of complete sample

	mean	sd	min	max
Co-authors per publication (log)	1.73	1.74	0	7.60
S–I collaborations (log)	0.39	0.62	0	2.80
Industry funding	0.14	0.10	0	1
Applied research	2.73	0.85	1	4
Teaching workload	26.28	22.34	0	100
Professor	0.21	0.41	0	1
Postdoc	0.27	0.44	0	1
Other	0.52	0.50	0	1
Female (=1)	0.38	0.48	0	1
Discipline: Computer Science and Mathematics	0.14	0.34	0	1
Discipline: Engineering	0.16	0.37	0	1
Discipline: Humanities	0.10	0.30	0	1
Discipline: Life Sciences	0.08	0.27	0	1
Discipline: Medicine	0.12	0.33	0	1
Discipline: Physics and Chemistry	0.14	0.35	0	1
Discipline: Social Sciences	0.26	0.44	0	1
University of Applied Sciences (=1)	0.25	0.43	0	1
N	1057			

Table 7
Multinomial logistic regression on scientist profiles with sub-sample excluding scientists from Social Sciences and Humanities.

	Categories of dependent variable:		
	Impactful	Commercializing	Ambidextrous
Bonding Social Capital			
Co-authors per publication (log)	3.240***	−0.506	5.639***
	(0.466)	(0.348)	(1.380)

(*continued on next page*)

Table 7 (*continued*)

	Categories of dependent variable:		
	Impactful	Commercializing	Ambidextrous
Co-authors per publication (log)^2	−0.470***	0.049	−1.060***
	(0.146)	(0.077)	(0.341)
Bridging Social Capital			
S–I collaborations (log)	0.184	1.085***	0.802***
	(0.195)	(0.227)	(0.294)
Linking Social Capital			
Industry funding	1.646	1.351	5.767***
	(1.252)	(1.487)	(1.725)
Control variables			
Applied research	−0.279*	0.340	0.145
	(0.161)	(0.215)	(0.324)
Teaching workload	−0.005	0.003	−0.057***
	(0.007)	(0.008)	(0.015)
Professor	1.172***	1.099**	2.323***
	(0.331)	(0.500)	(0.688)
Postdoc	0.803***	0.405	1.480***
	(0.268)	(0.486)	(0.518)
Female (=1)	−0.411*	0.036	−0.376
	(0.249)	(0.379)	(0.481)
Discipline: Engineering	0.169	−0.779	0.714
	(0.463)	(0.581)	(0.678)
Discipline: Life Sciences	−0.705	−1.110	−15.566***
	(0.452)	(0.895)	(0.585)
Discipline: Medicine	−1.728***	−0.807	−2.356***
	(0.419)	(0.702)	(0.665)
Discipline: Physics and Chemistry	−0.722**	0.397	−0.443
	(0.361)	(0.465)	(0.557)
Univ. of Applied Sciences (=1)	0.121	−0.307	−0.015
	(0.454)	(0.604)	(0.714)
Constant	−3.274***	−3.736***	−9.144***
	(0.691)	(0.808)	(2.036)
N	683		
Wald Chi^2	2935.16		
Adj. R^2	0.3089		

Robust standard errors in parentheses.
***p<0.01, **p<0.05, *p<0.1.
Reference category for *Discipline*: Computer Science and Mathematics.
Reference category for *Academic rank*: Other (including PhD students and technical personnel).

Table 8
Distribution of scientists across the four quadrants with stricter threshold

Profiles	N	%
Ambidextrous	31	2.93
Commercializing	79	7.47
Impactful	226	21.38
Normal	721	68.21

Table 9
Multinomial logistic regression on scientist profiles with stricter threshold for high research performance.

	Categories of dependent variable:		
	Impactful	Commercializing	Ambidextrous
Bonding Social Capital			
Co-authors per publication (log)	3.321***	−0.309	5.098***
	(0.576)	(0.286)	(0.993)
Co-authors per publication (log)^2	−0.503**	0.037	−0.978***
	(0.196)	(0.066)	(0.284)
Bridging Social Capital			
S–I collaborations (log)	−0.095	0.978***	1.220***
	(0.201)	(0.196)	(0.331)
Linking Social Capital			
Industry funding	0.190	2.066**	5.613***
	(1.183)	(0.986)	(1.240)
Control variables			
Applied research	−0.126	0.458**	0.217
	(0.127)	(0.183)	(0.395)

(*continued on next page*)

Table 9 (*continued*)

	Categories of dependent variable:		
	Impactful	Commercializing	Ambidextrous
Teaching workload	−0.002	0.003	−0.052***
	(0.005)	(0.007)	(0.019)
Academic rank: Professor	0.980***	0.708**	1.561*
	(0.268)	(0.359)	(0.859)
Academic rank: Postdoc	0.864***	0.078	1.364**
	(0.235)	(0.378)	(0.603)
Female (=1)	−0.263	−0.142	−0.394
	(0.206)	(0.286)	(0.558)
Discipline: Engineering	1.079**	−0.719	1.003
	(0.439)	(0.521)	(0.736)
Discipline: Humanities	1.808***	−0.901	3.344***
	(0.504)	(0.700)	(1.092)
Discipline: Life Sciences	−0.753*	−1.217	−15.165***
	(0.427)	(0.876)	(0.786)
Discipline: Medicine	−1.357***	−0.576	−1.628**
	(0.423)	(0.567)	(0.750)
Discipline: Physics and Chemistry	−0.578	0.657*	−0.651
	(0.374)	(0.397)	(0.707)
Discipline: Social Sciences	1.093***	−0.516	−0.037
	(0.372)	(0.418)	(1.037)
Univ. of Applied Sciences (=1)	−0.234	−0.145	0.381
	(0.303)	(0.408)	(0.619)
Constant	−4.360***	−4.123***	−10.021***
	(0.617)	(0.706)	(1.575)
N	1057		
Wald Chi^2	1287.88		
Adj. R^2	0.2905		

Robust standard errors in parentheses.
***p<0.01, **p<0.05, *p<0.1.
Reference category for *Discipline*: Computer Science and Mathematics).
Reference category for *Academic rank*: Other (including PhD students and technical personnel).

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