Small Bus Econ (2024) 63:1321–1337
https://doi.org/10.1007/s11187-024-00869-4

RESEARCH ARTICLE

Driving change in higher education: the role of dynamic capabilities in strengthening universities' third mission

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Accepted: 31 December 2023 / Published online: 17 January 2024

Abstract Universities play a crucial role in social, economic, and technological development. Over the last decades, higher education systems have experimented with multiple transformations due to social demands, socioeconomic paradigms, and external shakeouts. Even though teaching and research are still the core functions of universities, other activities are emerging within/beyond the universities' scope and boundaries to configure the "third mission." Despite the increasing importance of universities' third mission, little is known about the role of dynamic capabilities underpinning the configuration of the third mission across higher education systems. Using a unique longitudinal dataset that captures the German higher education landscape from 2000 to 2016, we investigate the effect of dynamic teaching/research capabilities for achieving the third university mission (knowledge transfer and technology commercialization). Our results reveal tensions between complementary and substitution effects when pursuing universities' three missions (teaching, research, and knowledge transfer and technology commercialization), requiring university managers' and policymakers' strategic decisions. We provide implications for university managers and the university community as well as policymakers during the re-configuration process of becoming more entrepreneurial and innovative, highlighting the relevance of effectively managing universities' dynamic capabilities.

Plain English Summary Universities have undergone significant transformations in recent decades, responding to societal demands, economic shifts, and external pressures. The third mission of universities thereby serves as a driving force and encompasses endeavors that go beyond traditional academic functions, such as knowledge transfer and technology commercialization. Despite its increasing importance, little is known about the underlying mechanisms that lead to third mission outcomes. To shed light on this crucial topic, this paper delves into the impact of dynamic teaching and research capabilities on achieving the third mission's goals. Our findings reveal goal conflicts that universities face in balancing their three missions, requiring university managers and policymakers to make strategic decisions to navigate these tensions effectively. As universities aim to become more entrepreneurial and innovative, effectively managing dynamic capabilities and making strategic decisions

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becomes paramount during reconfiguration processes, enabling universities to unlock their full potential for economic, technological, and societal impacts.

Keywords Third mission of universities · Knowledge transfer · Entrepreneurial universities · Ordinary capabilities · Dynamic capabilities · Strategic decision-making

JEL Classification I23 · O31 · O33

1 Introduction

Over the last decades, worldwide higher education systems have been exposed to multiple transformations derived from "stakeholder pressures," such as the emergence of new economic and technological paradigms (Audretsch, 2014), big societal challenges (Menter, 2023; Pinheiro et al., 2017), the United Nations' sustainable development goals (Guerrero & Lira, 2023), economic crises (Lehmann et al., 2018), and pandemics (Guerrero & Pugh, 2022; Siegel & Guerrero, 2021). In these transformation processes, even though teaching and research are still considered the core functions of universities, other activities have impregnated entrepreneurial/innovative orientations within/beyond universities' scope to configure the "third mission" (Compagnucci & Spigarelli, 2020).

Extant empirical research has evidenced that each higher education system has adopted specific university transformation pathways conditioned on organizational patterns, policymakers' strategies, and contextual conditions (Audretsch, 2014; Cunningham et al., 2022; Guerrero & Urbano, 2012; Guerrero et al., 2015; O'Shea et al., 2007). This explains why the accumulated literature has evidenced diverse domains (managerial, entrepreneurial, innovative, and social engagement) and operational measures (new lifelong learning models, university community spin-offs/start-ups, knowledge transfer, technology commercialization, and social engagement) applied to the third university mission in each higher education system (Berghaeuser & Hoelscher, 2020; Compagnucci & Spigarelli, 2020; Guerrero et al., 2023).

Universities require organizational-level dynamic capabilities to navigate through these organizational transformation processes and ensure long-term survival (Leih & Teece, 2016). O'Reilly et al. (2019) show that dynamic capabilities are especially important for knowledge transfer activities, hence for the realization of the third university mission. These findings are confirmed by Stolze and Sailer (2022) who find that dynamic capabilities positively affect third mission advancement. Despite calls from scholars to develop dynamic capabilities to enable transformation processes in higher education institutions (Guerrero et al., 2021; Yuan et al., 2018), little is still known about the role of dynamic capabilities underpinning the configuration of the third mission across higher education systems. Inspired by this academic gap, this paper theorizes about the dynamic capabilities configuring the third university mission related to knowledge transfer and technology commercialization. More concretely, we pay attention to the effect of ordinary and dynamic teaching/research capabilities on achieving the third mission in the German higher education system. Whereas ordinary capabilities refer to existing skills and routines, dynamic capabilities refer to the ability to adapt, innovate, and reconfigure these capabilities to respond to changing circumstances and seize new opportunities (Schriber & Löwstedt, 2020). We assume that pre-existing ordinary teaching/research capabilities combined with emergent dynamic teaching/research capabilities positively contribute to the configuration of the third university mission, considering potential substitution effects. With a unique longitudinal dataset that captures the German higher education landscape from 2000 to 2016, we test this assumption using zero-inflated negative binomial regressions. Our results reveal the importance of managing dynamic teaching/research capabilities to configure the third university mission in Germany.

Our study offers both theoretical and practical contributions. First, we extend the discussion about the role and impact of dynamic capabilities in relation to universities' third mission, enabling universities to be flexible and adaptive to change and highlighting the need for the strategic management of universities (Navarro & Gallardo, 2003). Second, we theorize about the (complementary or substitution) effects of ordinary and dynamic capabilities in the configuration of third mission outcomes (Guerrero et al., 2021; Heaton et al., 2020, 2023) by proposing a tested conceptual framework and evidencing the rivalry in the allocation of resources. Third, our study provides strategic insights for university managers and the university community as well as policymakers that could

be useful during the re-configuration or rejuvenation processes for becoming more entrepreneurial, as there are tensions between complementary and substitution effects when pursuing universities' three missions (teaching, research, and knowledge transfer and technology commercialization), requiring strategic decisions by university managers and policymakers (Heaton et al., 2019; Teece, 2023).

The remainder of our paper is structured as follows. The second section describes the theoretical framework by outlining the evolution of the third university mission and the contribution of dynamic capabilities to the third university mission (e.g., knowledge transfer and technology commercialization). Section 3 explains the adopted methodological approach. Section 4 shows the results, followed by Sect. 5 that discusses the contributions, implications, limitations, and future avenues of research. A final section concludes.

2 Theory development

2.1 The evolution of the third university mission

Several authors have called the "first academic revolution" when the university integrated research along with teaching as a core activity in the late nineteenth and early twentieth century, as well as the "second academic revolution" when the university impregnated the innovative and entrepreneurial orientation in the twenty-first century (Etzkowitz et al., 2000; Klofsten et al., 2019; Philpott et al., 2011). Behind each revolution, universities have experimented with multiple internal pressures (restricted sources of funding, growing/reducing numbers of students) and external pressures (increasing social demands, higher educational reforms, new socioeconomic paradigms, financial/economic crises, and pandemics) (Audretsch, 2014; Clark, 1998; Guerrero & Pugh, 2022; Guerrero & Urbano, 2012; Laredo, 2007; Menter, 2023). Consequently, these internal and external pressures have importantly shifted the university's primary focus on performing teaching and research by adding a third mission perceived as a "contribution to society" in a broad sense (Compagnucci & Spigarelli, 2020).

Understanding the third university mission demands contextualizing university adaptation, response, or transformation in the function of certain events. In this respect, Audretsch (2014) explains multiple historical facts/events that have influenced the introduction of an innovative and entrepreneurial orientation within North American universities. In this vein, North American universities legitimized the third mission, understood as the contribution to economic and social well-being, derived from university outcomes related to knowledge generation, technological inventions, and commercialization via spin-offs, and intellectual property mechanisms like patents and licenses (Audretsch, 2014; O'Shea et al., 2008). In this context, directly or indirectly, the legislation reinforced the legitimization of the third university mission (e.g., the Bayh-Dole Act) as well as the emergence of the phenomenon of "academic entrepreneurship" within universities (Dabić et al., 2022; Grimaldi et al., 2011; Lockett et al., 2005; Siegel & Wright, 2015). It was unsurprising that adaptative transformation legislative patterns were implemented worldwide, aiming to foster the socioeconomic contribution of universities via educational, technological, innovative, and entrepreneurial outcomes (Cunningham et al., 2019, 2021; Gores & Link, 2021).

In the UK higher education context, for example, the official higher education statistics offices have legitimized the third university mission by requesting specific information about university spin-offs, research contracts, grants, intellectual property, patents, licenses, and other qualitative metrics (Guerrero et al., 2015). Undoubtedly, the UK university's third mission contributions to educational and regional growth have been influenced by the implementation of the 2014 UK's Research Excellence Framework, which is focused on distributing public funds according to the university impacts (Audretsch et al., 2022). Similarly, the German higher education system has dramatically changed over the last two to three decades as a result of multiple federal/state programs (e.g., Innovative Hochschule, Real-World Laboratories, German Excellence Initiative) aiming to foster an innovative "third university mission" (Berghaeuser & Hoelscher, 2020; Graf & Menter, 2022). In the German context, given the public interventions, the third university mission has been understood as (a) knowledge transfer and technology commercialization (patents, research collaborations, consulting), (b) further education (advanced professional programs, short-term certificate studies), and (c) social engagement (community service, civic engagement, social

entrepreneurship) (Henke et al., 2016a, 2016b; Pasternack et al., 2015). Indeed, a recent study has shown that German universities' statements, representing the university management view, have effectively impregnated knowledge transfer and technology commercialization orientation (Berghaeuser & Hoelscher, 2020).

Based on these arguments, at the contextual level, the understanding and metrics of the third university mission depend on the particularities of each higher education system. At the organizational level, little is known about how university leaders in each particular higher educational system have internally defined, visualized, communicated, implemented, and operationalized the meaning of the third mission—where innovative and entrepreneurial orientations are not merely the creation of spin-offs or knowledge transfer and technology commercialization mechanisms but rather an attitude or behavior in the daily academic life for all members within the academic community (Klofsten et al., 2019). For instance, among the university community members, tensions arise (Philpott et al., 2011), as well as ambiguities in their roles (Lam, 2010) due the internal capacity restrictions, impeding the realization of entrepreneurial and innovative objectives. Based on these arguments, we assume the (complementary/substitutive) role of organizational-level dynamic capabilities in the primary university activities (teaching and research) as critical levers in the configuration of the third university mission (Guerrero et al., 2021; Heaton et al., 2019; O'Reilly et al., 2019).

2.2 The role of dynamic capabilities in the configuration of the third university mission

The concept of ordinary and dynamic capabilities is well established, and researchers have largely used these concepts to explain diverging performance paths across organizations (Teece, 2007). While ordinary capabilities are understood as organizational abilities (or prerequisites) to perform efficiently (do things right) well-delineated technical tasks through a core focus on operations, administration, and governance (Teece, 2014), dynamic capabilities are understood as the organizational ability to integrate, build, and reconfigure internal and external capabilities to address changing business environments (Teece et al., 2016: 8). In this view, dynamic capabilities represent the ability of managers to conceive new combinations of pre-existing organizational routines and entrepreneurial management to pursue sustaining competitiveness (Teece, 2023: 122), as well as to address rapidly changing environments (Helfat et al., 2007; Teece et al., 1997). According to Teece (2007), dynamic capabilities can be categorized into sensing (identification and assessment of an opportunity), seizing (mobilization of resources to address an opportunity and to capture value from doing so), and transforming (continued renewal), with a core focus on effectiveness (doing the right things).

In higher education, researchers have recognized that both ordinary and dynamic capabilities enable universities to fulfill the third mission by adopting an entrepreneurial and innovative paradigm (O'Reilly et al., 2019). For example, Navarro and Gallardo (2003) documented the university's strategic change by configuring the third mission to respond to the greater social demands. Then, Yuan et al. (2018) evidenced how universities significantly enhance third mission outcomes (e.g., knowledge transfer and technology commercialization) by orchestrating university assets and impregnating entrepreneurial/innovative behaviors within the university community. Recently, Schriber and Löwstedt (2020) have shown the role of ordinary and dynamic capabilities in responding to dynamically changing environments. A common pattern in these studies has been how dynamic capabilities are represented by the university managers' abilities to redirect resources (skilled personnel, facilities, equipment, and processes) and core activities (teaching and research) toward a sense of opportunities, prioritize the investment, and transform them to keep it resilient and aligned with the ecosystem and stakeholders (Heaton et al., 2020). However, adopting dynamic capabilities to understand universities' third mission configuration requires a systemic-level approach by considering internal interdependencies to determine the most critical (Heaton et al., 2019). According to Heaton et al. (2019), teaching-research-commercialization interdependency poses a considerable challenge to university managers, who must decide whether and how to manage it, and the extent to which it can be managed. Therefore, we need to understand how ordinary and dynamic capabilities in teaching and research affect third mission outcomes in a systemic way (Heaton et al., 2019, 2020, 2023), particularly whether ordinary and dynamic teaching/

research capabilities may complement or substitute each other (see examples in Table 1).

2.3 Hypotheses development

Regarding teaching capabilities, universities with an innovative and entrepreneurial orientation are characterized by high-quality teaching outcomes (Guerrero & Urbano, 2012) and by sustainable opportunities in implementing new teaching business models (Guerrero et al., 2021). Implicitly, to pursue a sustained income and performance, university managers efficiently allocate the available resources (ordinary capabilities) to achieve the traditional students' demand for university educational programs, as well as to achieve the high-quality academic standards required by the labor market (Heaton et al., 2019) and higher education agencies (Audretsch et al., 2022). Directly or indirectly, the efficient achievement of traditional educational programs endows the university community (students, managers, and staff) with certain dynamic capabilities enabling them to identify new teaching opportunities, behave entrepreneurially, and contribute to the third university mission (Compagnucci & Spigarelli, 2020; Heinonen & Hytti, 2010). For example, due to external pressures (e.g., technological and digital advances), well-recognized university faculty have identified new educational opportunities based on the student's needs (e.g., short-term certifications, specializations or specific competencies) and have reconfigured new educational offers by proposing innovative academic programs with multiple flexible modalities in-person, online, and hybrid (Guerrero et al., 2021). Given the emergence of new market segmentations, university managers have re-evaluated and seized resources to expand the offer by taking advantage of rapid technical/digital teaching–learning advances, such as massive open online courses (MOOCs), digital campuses connected via devices and virtual reality, and telepresence education using artificial intelligence (Dillenbourg, 2008; Heaton et al., 2019). It explains why MOOCs have been considered "the most significant technological advance in the pedagogic part of higher education in a millennium" and why university managers have sensed/seized these opportunities (Teece, 2018: 98). The most successful MOOCs or digital campuses have directly or indirectly enhanced knowledge transfer and technology commercialization via new higher education business models and digital educational platforms (Audretsch & Belitski, 2021). Consequently, in the most successful cases, university managers have invested resources in exploiting opportunities and ensuring sustained performance (Guerrero et al., 2021). In this assumption, universities' ordinary teaching capabilities (high-quality educational programs) and dynamic capabilities (new digital educational certifications) have supported the third university mission, especially the most innovative educational trends, by providing the most updated knowledge/skills critical for developing entrepreneurial innovations that would be transferred and commercialized. Based on these arguments, we propose the following hypotheses:

H1a: Ordinary teaching capabilities positively contribute to the configuration of the third university mission.
H1b: Dynamic teaching capabilities positively contribute to the configuration of the third university mission

Regarding research capabilities, universities with an innovative and entrepreneurial orientation are characterized by high-quality research outcomes, as well as sustainable research and development outcomes (Guerrero et al., 2015). University managers effectively cover the research standards required by allocating the resources to researchers to achieve the university's evaluations and higher education agencies (Etzkowitz, 2003). Research activities constitute a prerequisite for knowledge transfer and technology commercialization (Compagnucci & Spigarelli, 2020). While a signal regarding ordinary research capabilities is knowledge dissemination via publications (Cunningham & Menter, 2021; Graf & Menter, 2022), more disruptive research outcomes are strongly related to knowledge spillover effects from the publications. In this view, the research citations represent the proxy of an advanced representation of dynamic research capabilities that facilitate the emergence of new collaborative projects among multiple scientists from local/international research centers, labs, or worldwide universities (Romero et al., 2021). For example, due to societal and stakeholder pressures, well-recognized university researchers have identified new research scholarly impact opportunities considering innovative solutions to societal challenges (e.g.,

Table 1 Teaching-research ordinary/dynamic capabilities' complementary or substitution effects on the third university mission

University Missions	Ordinary capability	Dynamic capability	Complementary effect	Substitution effect
Teaching	University managers effectively cover the educational programs' demands required by students' needs and labor market competencies (Compagnucci & Spigarelli, 2020). University managers allocate the resources to achieve this activity and generate skilled graduates (Guerrero et al., 2015)	University managers identify the potential adoption or expansion of new educational business models (online, hybrid, MOOCs) to offer new certifications to existing students, expand the number of students, or capture new student segments (long-life learning) (Heaton et al., 2019; Teece, 2018). Directly or indirectly, the university is generating social impacts and well-being for the students and university (Guerrero et al., 2021)	Teaching-research interdependency may enrich the quality of teaching, the number of publications, and social engagement (Compagnucci & Spigarelli, 2020; Heaton et al., 2020). For example, the development of a specific granted project with the participation of different stakeholders where experimented faculty and skilled students are actively involved in developing entrepreneurial/ innovative solutions to specific societal problems or priorities (Guerrero & Pugh, 2022). In this way, university managers will simultaneously allocate existing resources or seize new ones to ensure the project's success and ensure university's sustained performance (Heaton et al., 2020)	Teaching-research interdependency may detract from the amount/quality of teaching done by faculty engaged in research and/or knowledge transfer/technology commercialization (Heaton et al., 2019). For example, faculty (inventors and researchers) will be more incentivized to invest time in publications or inventions instead of teaching. In this regard, university managers could redefine faculty categories/numbers according to their profiles/experiences and sense resources to prioritize better-performance projects or profitable new business models
Research	University managers effectively cover the research standards required by allocating the resources to researchers to achieve the university's evaluations and higher education agencies	University managers identify the potential expansion of new research business models or collaborative projects with important stakeholders to generate scholarly impacts and university performance (Audretsch et al., 2022) by developing entrepreneurial innovations that could be commercialized or transferred via intellectual property		

climate, equality, and sustainability) and external crisis (e.g., financial, natural disasters, and pandemics) (Audretsch et al., 2022; Guerrero & Pugh, 2022). In this context, university managers should prioritize and seize resources in those research activities that represent sustainable competitive advantage (Heaton et al., 2020), a priority for the university stakeholders (Siegel & Guerrero, 2021), as well as a substantial contribution to socioeconomic development (Audretsch et al., 2022). In this assumption, universities' ordinary research capabilities (publications) and dynamic research capabilities (dissemination) support knowledge transfer and technology commercialization, especially the most innovative research, by providing the most updated knowledge and human talent critical for developing sustained research impacts. Based on these arguments, we propose the following hypotheses:

H2a: Ordinary research capabilities positively contribute to the configuration of the third university mission.
H2b: Dynamic research capabilities positively contribute to the configuration of the third university mission

Regarding mixed teaching-research capabilities, the allocation of resources and capabilities depends on the orientation of each organization as well as its position within the ecosystem (Belitski & Heron, 2017). The first general assumption is a complementing effect of universities' ordinary and dynamic capabilities in the third mission outcomes (Yuan et al., 2018). Teaching-research interdependency may enrich the quality of teaching, the number of publications, and social engagement (Compagnucci & Spigarelli, 2020; Heaton et al., 2020), for example, the development of a specific granted project with the participation of different stakeholders where experimented faculty and skilled students are actively involved in developing entrepreneurial/innovative solutions to specific societal problems or priorities (Guerrero & Pugh, 2022). In this way, university managers will simultaneously allocate existing resources or seize new ones to ensure the project's success and ensure the university's sustained performance (Heaton et al., 2020). A second general assumption is a rivalry in allocating resources and capabilities between teaching and research activities (Guerrero & Urbano, 2012). Teaching-research interdependency may detract from the amount/quality of teaching done by faculty engaged in research, consequently, those involved in knowledge transfer and technology commercialization activities (Heaton et al., 2019). For example, faculty (inventors and researchers) will be more incentivized to invest time in publications or inventions instead of teaching. As resources are scarce, university managers must make strategic decisions about their allocation. University managers could redefine faculty categories/numbers according to their profiles/experiences and sense resources to prioritize better-performance projects or profitable new business models. It represents an "organization face trade-offs in choosing between alternative capability development" (Wang & Ahmed, 2007: 41). Marzocchi et al. (2019) reinforce these findings, emphasizing different pathways induced by the underlying allocation and deployment of resources and capabilities. In this assumption, we recognize that a rivalry in allocating ordinary/dynamic teaching-research capabilities will negatively affect the configuration of universities' third mission. It explains the evolution of an innovative and entrepreneurial orientation that allows capturing value-added from the primary university activities (teaching and research). Based on these arguments, we propose the following hypothesis:

H3: A substitution effect between ordinary/dynamic teaching-research capabilities negatively contributes to the configuration of the third university mission

Figure 1 shows the proposed theoretical model investigating the direct effect of ordinary and dynamic teaching capabilities (hypotheses 1a and 1b) and ordinary and dynamic research capabilities (hypotheses 2a and 2b) on the third university mission (knowledge transfer and technology commercialization), as well as the mixed effect of both ordinary and dynamic capabilities in the domains of teaching and research (hypothesis 3).

3 Methodology

3.1 Data collection

Our empirical analyses are based on a unique longitudinal dataset of 1478 observations that captures the German higher education system landscape integrated

Fig. 1 Theoretical model

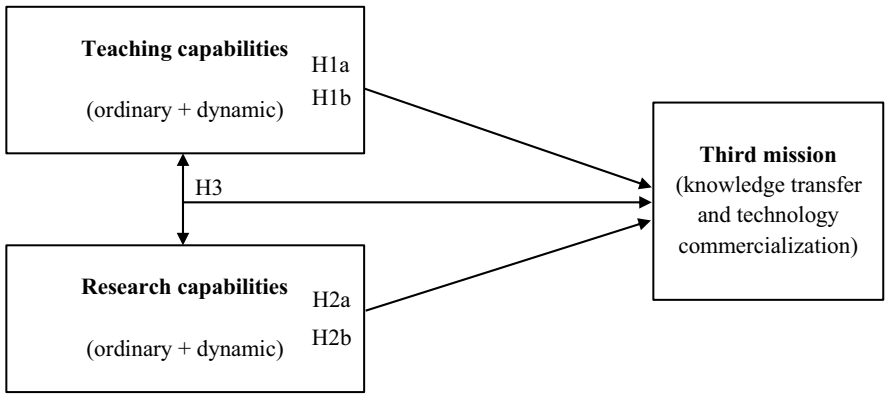

Table 2 Operationalization

Variable	Operationalization	Source
Third university mission: knowledge transfer and technology commercialization	Number of university patents per German university	REGPAT and HAN databases
Teaching ordinary capabilities	Number of students per professor per German university	German Statistics Office
Teaching dynamic capabilities	Number of massive open online courses (MOOCs) in natural sciences offered per German university	University websites, email correspondence with analyzed universities
Research ordinary capabilities	Number of publications per professor per German university	Scopus, German Statistics Office
Research dynamic capabilities	Number of highly cited publications in natural sciences per German university	Scopus
Gender diversity	Share of female university research fellows in comparison to all university research fellows per German university	German Statistics Office
Industry orientation	Amount of university third-party funds from industry per professor (in 1,000 €) per German university	German Statistics Office
Public funding	Dummy variable indicating funding received from the German Excellence Initiative per German university	Federal Ministry of Education and Research
Size	Number of students in natural sciences per German university	German Statistics Office

by 90 universities within a timeframe from 2000 to 2016. To build this dataset, we combined secondary sources of information such as the OECD REGPAT and the 2019 HAN databases and the Scopus database as well as university websites. Further information was retrieved from the German Statistics Office.

3.2 Variables

Table 2 shows the variables included in our analyses.

Our dependent variable, *the third university mission*, linked with technology and knowledge commercialization, is measured by the number of university patents from each German university. Previous empirical studies have used the number of patents granted by universities as an appropriate proxy to capture knowledge transfer and technology commercialization as an outcome of the third university mission (Laredo, 2007). Given the drivers and particularities of the German higher education system, knowledge

transfer and technology commercialization represent a central part of the self-description of the third mission of German universities (Berghaeuser & Hoelscher, 2020; Graf & Menter, 2022; Henke et al., 2016a, 2016b; Pasternack et al., 2015).

Four independent variables were used to capture the impact of ordinary and dynamic capabilities in the domains of teaching and research on entrepreneurial outcomes. First, *ordinary teaching capabilities* are operationalized by the number of students per professor and university. According to Heaton et al. (2019), university managers effectively allocate resources to achieving ordinary or routine activities. In this view, an efficient metric for capturing the allocation of resources in traditional teaching models is the number of students per university faculty. Second, *dynamic teaching capabilities* are measured by the number of MOOCs per university. According to Teece (2018), MOOCs represent a dynamic capability derived from the university managers' ability to sense and seize new opportunities given the contemporary educational trends and massive students' needs. In this view, the number of MOOCs per university represents the university distinction between identifying a sustained contribution and the achievement of the third university mission (Guerrero et al., 2021; Menter, 2022). Third, *ordinary research capabilities* are operationalized by the number of publications per professor. Likewise teaching, university managers are focused on effectively allocating resources for research to achieve the required standard by higher education agencies (Audretsch et al., 2022). Therefore, the number of publications per university researcher is the most appropriate measure to capture a successful allocation of resources and capture the university research outcomes (Menter et al., 2018). Fourth, *dynamic research capabilities* are measured by the number of highly cited publications per university. This metric evidenced the scholarly impact of the university's research on how others disseminate the knowledge produced by university researchers (Audretsch et al., 2022).

Our control variables are based on previous studies. We include four control variables[1]: (a) *gender diversity* measured by the share of female university research fellows compared to all university research fellows (Menter, 2022), (b) *industry orientation* measured by the amount of university third-party funds from industry per professor and per university (in 1000 €) (O'Reilly et al., 2019), (c) *public funding* measured as a dummy variable indicating whether a university received public funding from the German Excellence Initiative or not[2] (Menter et al., 2018), and (d) *size* measured by the number of students per university[3] (Guerrero et al., 2021).

3.3 Statistical model

Given the nature of our dependent variable (count variable with excessive zeros; 868 out of 1717 observations of our dependent variable assume the value zero), we use zero-inflated negative binomial regressions[4] to test our proposed model (see Ghazal & Zulkhibri, 2015; Ghio et al., 2019; Siegel & Wessner, 2012). We thereby employ robust standard errors. We further include year and region dummies. Besides investigating the direct linear effect of ordinary and dynamic teaching and research capabilities (see M1 to M2), we are interested in the interaction of the respective ordinary and dynamic capabilities, particularly whether ordinary and dynamic teaching and research capabilities are complements or substitutes. M3 to M7 thus test our full model with all control variables and interaction terms.

As a robustness test, we use a logistic panel regression approach, converting our dependent count variable (number of patents) into a dummy variable (the third university mission identified as knowledge transfer and technology commercialization). We again employ robust standard errors and insert the same control variables. Besides investigating the

[1] We specifically focus on natural sciences, as associated disciplines are more likely to engage in formal knowledge transfer and technology commercialization activities, hence commercializing newly created knowledge e.g., via patenting (see Abreu & Grinevich, 2013).

[2] See Menter et al. (2018) for a detailed description of the scope and aim of the German Excellence Initiative, a public policy initiative which aimed at promoting cutting-edge research at universities: "The Excellence Initiative has sparked a pioneering spirit at universities, along with new ideas and diverse new forms of cooperation between universities and non-university research institutions" (DFG, 2013: 13).

[3] Students in the field of science, technology, engineering, and math (STEM).

[4] The appropriateness of the zero-inflated negative binomial regression model against the standard negative binomial model is confirmed by Vuong tests (Cameron & Trivedi, 2009; Vuong, 1989).

direct linear effect of ordinary and dynamic teaching and research capabilities (see M8 to M9), we are interested in the interaction of the respective ordinary and dynamic capabilities, particularly whether ordinary and dynamic teaching and research capabilities are complements or substitutes. M10 to M14 thus test our full model with all control variables and interaction terms.

4 Results

4.1 Contextualization

We observe large differences in the German higher education landscape regarding descriptive statistics, with some universities being very innovative across all three university missions (see Table 3). In contrast, other universities rather lag behind, as indicated by the value of zero in dynamic teaching capabilities (first university mission), ordinary and dynamic research capabilities (second university mission), and knowledge transfer and technology commercialization (third university mission). Also, the ordinary teaching and research capabilities differ significantly, with some universities focusing on teaching without pronounced research activities. However, not only do activities devoted to teaching, research, knowledge transfer, and technology commercialization within universities vary, but also, the general profile of German universities differs significantly, with some universities having a strong focus on natural sciences and others having a core focus on social sciences. As a result, also the industry orientation varies significantly.

The correlation matrix reveals further insights into the relationship between all three university missions. High bivariate correlations can be found between ordinary and dynamic research capabilities and knowledge transfer and technology commercialization activities ($r=0.58$ | $r=0.51$). In contrast, the bivariate correlations between ordinary and dynamic teaching capabilities and knowledge transfer and technology commercialization activities are low ($r=0.12$ | $r=0.10$). Further, a strong industry orientation seems to be strongly related to ordinary research capabilities ($r=0.55$). University size also shows high bivariate correlations with ordinary and dynamic research capabilities ($r=0.62$ | $r=0.53$) and

Table 3 Descriptive statistics and correlation matrix

Variable	Obs	Mean	SD	Min	Max	1	2	3	4	5	6	7	8
1. Third university mission	1717	3.42	6.45	0	50.00	1.00							
2. Teaching ordinary capabilities	1572	59.11	27.43	2.55	267.00	0.12***	1.00						
3. Teaching dynamic capabilities	1717	0.02	0.27	0	7.00	0.10***	0.00	1.00					
4. Research ordinary capabilities	1487	3.86	2.63	0	20.18	0.58***	0.17***	0.12***	1.00				
5. Research dynamic capabilities	1717	9.74	23.77	0	206.00	0.51***	0.10***	0.27***	0.49***	1.00			
6. Gender diversity	1611	0.35	0.10	0.02	0.92	−0.01	0.15***	0.04*	0.07**	0.23***	1.00		
7. Industry orientation	1548	43.14	46.65	0	482.09	0.30***	0.24***	0.03	0.55***	0.15***	−0.20***	1.00	
8. Size	1629	6349	6367	0	39,098	0.66***	0.32***	0.13***	0.62***	0.53***	−0.02	0.34***	1.00
9. Public funding (dummy)	1717	0.14	0.35	0	1								

Table 4 Estimation results

	M1	M2	M3	M4	M5	M6	M7
Teaching ordinary capabilities	0.022***	−0.011***	−0.010	−0.011***	−0.010***	−0.010***	−0.013
	(0.008)	(0.003)	(0.010)	(0.003)	(0.003)	(0.003)	(0.010)
Teaching dynamic capabilities	0.050	0.016	0.016	0.058	0.972***	0.022	0.675***
	(0.105)	(0.047)	(0.047)	(0.117)	(0.276)	(0.042)	(0.259)
Research ordinary capabilities	0.207***	0.051**	0.056	0.051**	0.055***	0.114***	0.078
	(0.040)	(0.021)	(0.092)	(0.021)	(0.021)	(0.025)	(0.090)
Research dynamic capabilities	0.014***	0.003**	0.003**	0.003**	0.003**	0.017***	0.017***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)
Teaching ordinary capabilities × research ordinary capabilities			−0.000				0.001
			(0.001)				(0.001)
Teaching dynamic capabilities × research dynamic capabilities				−0.000			−0.001
				(0.001)			(0.001)
Teaching ordinary capabilities × teaching dynamic capabilities					−0.017***		−0.009**
					(0.005)		(0.004)
Research ordinary capabilities × research dynamic capabilities						−0.002***	−0.002***
						(0.000)	(0.000)
Gender diversity		−0.750	−0.761	−0.750	−0.763*	−1.433***	−1.340***
		(0.462)	(0.506)	(0.462)	(0.460)	(0.489)	(0.506)
Industry orientation		−0.005***	−0.005***	−0.005***	−0.005***	−0.006***	−0.005***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Public funding		0.120	0.120	0.120	0.123	0.159*	0.158*
		(0.080)	(0.080)	(0.080)	(0.080)	(0.083)	(0.083)
Size		0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1478	1478	1478	1478	1478	1478	1478

Note: this table reports the results of zero-inflated negative binomial regressions. The estimation is based on a sample of 90 German universities within a timeframe from 2000 to 2016. The dependent variable is the number of university patents as an outcome of the third university mission. Robust standard errors are in parentheses

*$p<0.10$, **$p<0.05$, ***$p<0.01$

knowledge transfer and technology commercialization activities ($r=0.66$).

4.2 The direct effect of ordinary and dynamic teaching/research capabilities

Table 4 shows the statistical analysis results to test our proposed hypotheses.

Regarding teaching capabilities, our results show that the third mission of universities is not, per se, positively influenced by German universities' ordinary and dynamic teaching capabilities. Whereas ordinary teaching capabilities show negative and statistically significant coefficients ($\beta_1=-0.022$; $p<0.01$ | $\beta_2=-0.011$; $p<0.01$ | $\beta_6=-0.010$; $p<0.01$), dynamic teaching capabilities reveal positive and significant coefficients ($\beta_5=0.972$; $p<0.01$ | $\beta_7=0.675$; $p<0.01$). An implicit explanation is that teaching is present in developing innovative and entrepreneurial capabilities equipping the university community (students, faculty, and staff) with capabilities enabling them to sense/seize new opportunities (Guerrero et al., 2021; Heinonen & Hytti, 2010). However, the effective contribution of these capabilities will depend on the audience and its entrepreneurial expectations that may not be fully captured in our proxies. Based on our results, we need to reject hypothesis 1a yet can confirm hypothesis 1b.

Regarding research capabilities, our results show that German universities' ordinary and dynamic research capabilities have a positive impact on the development of the third mission of universities. Both ordinary research capabilities ($\beta_1 = 0.207$; $p < 0.01$ | $\beta_6 = 0.114$; $p < 0.01$) as well as dynamic research capabilities ($\beta_1 = 0.014$; $p < 0.01$ | $\beta_7 = 0.017$; $p < 0.01$) show positive and significant coefficients. Previous empirical studies have found that universities with more advanced ordinary and dynamic research capabilities perform better in knowledge transfer and technology commercialization (Berghaeuser & Hoelscher, 2020; Graf & Menter, 2022; O'Reilly et al., 2019). A plausible explanation is that ordinary and dynamic research capabilities result from the universities' ability to sense opportunities, seize opportunities, and transform research capabilities to meet the demands of knowledge transfer and technology commercialization (Heaton et al., 2019, 2020). Based on our results, we find support for hypotheses 2a and 2b.

4.3 The mixed effect of ordinary and dynamic teaching/research capabilities

Besides the (indicatively) positive linear impact of ordinary and dynamic teaching/research capabilities, the interaction effect among ordinary and dynamic teaching and research capabilities ($\beta_7 = -0.009$; $p < 0.01$ | $\beta_7 = -0.002$; $p < 0.01$) shows a negative and statistically significant coefficient, indicating a potential substitutive impact of ordinary and dynamic capabilities in the domains of teaching and research. A plausible explanation for the substitution effect is that innovativeness in education (by offering MOOCs) and in research (by engaging in high-impact research) might consume internal capacities and resources in knowledge transfer and technology commercializing (by patenting research). The same holds for all other combinations of teaching and research ordinary and dynamic capabilities, having a combined negative yet not statistically significant effect on third mission outcomes (knowledge transfer and technology commercialization). Again, engagement in the domain of (innovative) teaching and research might consume internal capacities in knowledge transfer and technology commercialization (e.g., by patenting research). Whereas university size and especially a focus on natural sciences seems to be further beneficial for the third mission outcomes of universities ($\beta_7 = 0.000$; $p < 0.01$), universities' industry orientation appears to be negatively associated with the third university mission of knowledge transfer and technology commercialization ($\beta_7 = -0.005$; $p < 0.01$). Hence, strong university-industry collaborations seem to offer fewer incentives for universities to transfer or commercialize new knowledge or technologies. Our results are robust and confirmed by our alternative logistic regression approach (see Table 5).

Universities thus need to make strategic decisions on how to invest their capacities and resources and which paths to pursue, i.e., innovativeness in the first mission (teaching) vs. innovativeness in the second mission (research) vs. innovativeness in the third mission (knowledge transfer and technology commercialization). These potential tensions might be further triggered by the different types of knowledge generated through the different types of innovative behavior. Whereas, for example, MOOCs (as an output of innovative teaching) represent an international entrepreneurial orientation of education to provide "update" capsules of knowledge to people in a flexible way across the globe, patents (as an output of the third mission) create very specific knowledge that is devoted to a rather limited group of individuals (Guerrero et al., 2021). Based on our results, we find support for hypothesis 3.

5 Discussion

5.1 Theoretical and practical contributions

Previous studies have highlighted that the strategic view of universities demands more academic debate (Audretsch & Belitski, 2022; Klofsten et al., 2019), especially nowadays, considering several externalities and exogenous effects (Kawamorita et al., 2020; Siegel & Guerrero, 2021). Our study contributes to these timely academic and policy-maker conversations. First, we extend the literature on dynamic capabilities by differentiating between ordinary and dynamic capabilities in the higher education context. We show that both ordinary and dynamic capabilities in the domains of teaching and research affect universities' third mission,

Table 5 Robustness test

	M8	M9	M10	M11	M12	M13	M14
Teaching ordinary capabilities	−0.008	−0.020*	−0.009	−0.020*	−0.019*	−0.019*	−0.009
	(0.013)	(0.010)	(0.012)	(0.010)	(0.010)	(0.010)	(0.011)
Teaching dynamic capabilities	2.172***	2.064**	1.944**	2.350**	40,176	1.944*	20,301***
	(0.755)	(0.920)	(0.895)	(0.972)	(0.000)	(0.993)	(1,168)
Research ordinary capabilities	0.801***	0.572***	0.729**	0.571***	0.564***	0.597***	0.731**
	(0.194)	(0.176)	(0.318)	(0.176)	(0.176)	(0.173)	(0.310)
Research dynamic capabilities	0.033**	0.011	0.012	0.011	0.011	0.042*	0.043*
	(0.016)	(0.013)	(0.013)	(0.013)	(0.013)	(0.024)	(0.026)
Teaching ordinary capabilities × research ordinary capabilities			−0.003				−0.003
			(0.004)				(0.004)
Teaching dynamic capabilities × research dynamic capabilities				−0.015**			2.361***
				(0.007)			(0.209)
Teaching ordinary capabilities × teaching dynamic capabilities					−482.4***		−244.4***
					(0.060)		(14.071)
Research ordinary capabilities × research dynamic capabilities						−0.005*	−0.005
						(0.003)	(0.003)
Gender diversity		−3.802	−3.957	−3.815	−3.756	−3.827	−3.922
		(3.023)	(3.005)	(3.025)	(3.029)	(3.013)	(2.992)
Industry orientation		0.001	0.002	0.001	0.001	0.001	0.002
		(0.005)	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)
Public funding		1.543*	1.550*	1.543*	1.520*	1.522*	1.500*
		(0.884)	(0.881)	(0.884)	(0.887)	(0.872)	(0.867)
Size		0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1478	1478	1478	1478	1478	1478	1478

Note: this table reports the results of logistic panel regressions. The estimation is based on a sample of 90 German universities within a timeframe from 2000 to 2016. The dependent variable is the existence of university patents as an outcome of the third university mission. Robust standard errors in parentheses

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

highlighting the need for the strategic management of universities. We thus provide relevant insights into how ordinary and dynamic capabilities (internal determinants) have been strongly related to German universities' third mission pathways over the last two decades (Graf & Menter, 2022). Especially innovative educational trends and the most innovative research support knowledge transfer and technology commercialization by providing the most updated knowledge for developing entrepreneurial innovations. Second, we extend the conversation about theorizing the (complementary or substitution) effect of ordinary and dynamic capabilities in the configuration of the third mission outcomes (Guerrero et al., 2021; Heaton et al., 2020, 2023) by proposing a tested conceptual framework and evidencing the rivalry in the allocation of resources. This study exposes the contribution and rivalry among dynamic teaching and research capabilities in configuring the third mission of universities (Guerrero et al., 2021; Romero et al., 2021). In this vein, this study also extends the academic discussion about the little attention paid to teaching capabilities in developing the third university mission (Guerrero & Urbano, 2012; Heinonen & Hytti, 2010). Third, our study provides strategic insights for university managers and the university community as well as policymakers that could be useful

during the re-configuration or rejuvenation processes for becoming more entrepreneurial, as there are tensions when pursuing universities' three missions (teaching, research, knowledge transfer, and technology commercialization), requiring strategic decisions by university managers and policymakers (Heaton et al., 2019; Teece, 2023). The development of the third university mission depends on ordinary and dynamic capabilities, which must be leveraged and managed. Hence, strategic decision-making about allocating and deploying resources and capabilities is required (Heaton et al., 2019, 2020).

5.2 Implications

Several implications emerge from our study. *For university managers*, universities should adopt an entrepreneurial orientation to transform old routines into new ones in knowledge-based dynamic environments (Teece, 2018, 2023). In this vein, university managers should transform universities' activities and shape (entrepreneurial) ecosystems through sui generis strategic acts that neither stem from routines nor give rise to new routines (Belitski & Heron, 2017; Heaton et al., 2019). This study provides insights into the relevance of dynamic capabilities and the rivalry in using ordinary and dynamic teaching/research capabilities, calling for effective management of resources to accomplish university missions. *For the university community*, the results provide some insights into the supportive role of teaching and research in developing entrepreneurial behaviors in accomplishing the German universities' third mission in terms of knowledge transfer and technology commercialization (Guerrero et al., 2021; Heinonen & Hytti, 2010; O'Reilly et al., 2019). However, the effectiveness in developing dynamic capabilities will depend not only on university strategies but also on potential university entrepreneurs' objectives, expectations, and needs. A good combination of educational programs and new knowledge-creation scenarios could generate significant outcomes for potential entrepreneurs and the university. *For policymakers*, this study provides insights into the relevance of engaging in teaching-research activities and the collaboration between universities and industries to generate value added in the region via knowledge transfer and technology commercialization. Hence, policy initiatives need to consider the scarce set of resources of universities/scientists (Audretsch et al., 2022; Mankins et al., 2014), as the simultaneous development of diverging ordinary and dynamic capabilities does not seem to be possible. A learning lesson from this study is the consideration of a long-term perspective of the higher education landscape that allows understanding universities' pathways to rethink the present/future strategies of universities.

5.3 Limitations and research agenda

This study has several limitations. The first limitation is associated with the proxy used to measure the university mission outcomes. Even though recent studies in the German context have recognized the impregnation of knowledge transfer and technology commercialization as the third university mission (Berghaeuser & Hoelscher, 2020), given the dataset definition, we did not include measures like spin-offs, start-ups, or contract revenues. Likewise, the proxies related to ordinary and dynamic teaching and research capabilities could be improved and refined. A natural extension of our study could be collecting data from surveys or retrospective case studies that allow measuring the objective/subjective particularities behind each university mission outcome to be captured. The second limitation is associated with our missing regional-industrial focus. We should have explored the regional context that is crucial for capturing the effect on the configuration of regional ordinary and dynamic capabilities. Therefore, future researchers should consider the regional dimension and the dual relationships between universities and regions; hence, universities' entrepreneurial and innovative ecosystems should be embedded ((Belitski & Heron, 2017; Heaton et al., 2019; Schaeffer et al., 2021). The third limitation is associated with the definition/measurement of rivalry effects of ordinary and dynamic capabilities on the third mission. A natural extension should be improving the theoretical approach for a better understanding of the rivalry (e.g., adopting asymmetries of information or agency theory approaches), as well as enhancing the testing by capturing in-depth longitudinal information about the university allocation strategy.

6 Conclusions

The objective of this paper was to theorize about the role of dynamic capabilities configuring the third university mission related to knowledge transfer and technology commercialization. Based on a unique longitudinal sample of German universities, this study provides empirical evidence about the tensions in using dynamic teaching and research capabilities to achieve the third university mission (knowledge transfer and research commercialization) in the German context. It highlights the relevance of effectively managing universities' ordinary and dynamic capabilities. In our role as social science researchers and university members, we would like to stimulate scholars from different social science fields to rethink more broadly the opportunities for making an impact with our research focus on developing universities' dynamic capabilities and begin doing so more often. We believe it is the perfect time to "make a difference" and "support the strategic entrepreneurial transformation of our workplaces" through our research, teaching, and interaction with multiple socioeconomic agents. Hence, we call for more strategic thinking and decision-making, enabling the adoption of an innovative and entrepreneurial paradigm and opening up new pathways for universities' third mission.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data Availability Not applicable

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