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Traditional, virtual, and digital intermediaries in university-industry collaboration: exploring institutional logics and bounded rationality

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ABSTRACT

University-industry collaboration now extends beyond traditional intermediary structures and logics, enabled by more contemporary virtual networks and digital formats. This however poses new strategic and operational challenges for effective and responsive knowledge transfer.

The purpose of this paper is to compare traditional models of knowledge transfer intermediaries in university-industry collaboration with emerging, virtual (network-based) and digital intermediaries by exploring their structures (thus institutional logics) and their services (their agency). We synthesise literature to form a comprehensive analytical framework to assess the structure and agency of twenty international knowledge transfer intermediaries from around the world. Further running a cluster analysis using multiple correspondence analysis method and following its results we propose a unique combination of institutional logic and bounded rationality lenses, which allowed us to identify four types of knowledge transfer intermediaries: *rigid, rigid-unbounded, agent-bounded and agile*. Our unique framework contributes to existing knowledge focused on traditional forms of knowledge transfer intermediaries, by identifying and positing institutional logics for emerging contemporary virtual and digital intermediaries in university-industry collaboration.

1. Introduction

The university-industry collaboration context is ripe for intermediation services, due to diverse stakeholders, polarised objectives and operational differences (Alexander et al., 2018; Temel et al., 2021). Despite joining the 'accounting for excellence' movement to become business-like (Ramirez, 2010), universities still differ from businesses in their basic rationale and motivations (Perkmann and Walsh, 2007). Knowledge Transfer Intermediaries (KTIs) assist in curating, processing and commercialising knowledge (Howells, 2006) and offering what Yusuf (2008, p. 1172) describes as "*bridging ties and interfaces…diagnosing needs and articulating the demand for certain kinds of innovation, by instituting a dynamic framework for change and working to achieve the change through financing and other means*". Drawing on some studies that have examined different aspects of intermediation and knowledge transfer intermediation (see Battistella et al., 2016; Doganova, 2013; Kodama, 2008; Lindkvist et al., 2019; Meyer and Kearnes, 2013; Yusuf, 2008) for the purpose of this study, we define knowledge transfer intermediation as *the process of managed and targeted facilitation occurring between universities and industrial partners* (that includes activities of technology and knowledge transfer).

Despite increasing numbers of KTIs in knowledge-based economies (Kodama, 2008; Watkins et al., 2015) our understanding of their structures, services and underpinning logics remain limited (Bodas Freitas et al., 2013; Dushnitsky and Klueter, 2017). Accordingly, empirical studies of knowledge transfer (dissemination, diffusion and adoption processes) confirm the activity as complex (Gera, 2012) and suffering many pervasive problems and pitfalls (Bruneel et al., 2010; Galán-Muros and Plewa, 2016; Lee, 1996).

Digitally-enabled, business-to-business platforms, are transforming contemporary global trade (Cusumano et al., 2019; Evans and Gawer, 2016) and thus opening up new market opportunities. With cloud-based marketplaces and commercial B2B collaboration platforms increasing exponentially; trends in digitisation are also fuelling industry-specific forms of knowledge transfer intermediation (for example Flintbox or iBridgenetwork) (Agrawal et al., 2015; Dushnitsky and Klueter, 2017).

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Whilst the recent global pandemic has amplified virtual connectivity and online collaboration in education, industry and our homes, and digitised learning platforms now exist across the majority of the world's university curricula, digital forms of university-business collaboration and knowledge transfer are still far less visible (Dushnitsky and Klueter, 2017) and in their infancy (Cahoy, 2021; Etzkowitz et al., 2019).

A recent study by Hayter et al. (2020) affirmed there is a need for a wider conceptualisation of knowledge exchange, beyond the traditional linear approaches to reflect the different routes, mechanisms and structures and the wider impact agenda. Contributing to this empirical deficit, there is also a paucity of macro-level analytical frameworks that assess the shift from traditional and more physically-based university-industry knowledge transfer to contemporary, virtual and digital platform-based intermediation. To clarify, physical KTIs inhabit dedicated premises (as traditional TTOs for example), whereas digital platforms imply a permanent digital structure (a web-based platform). Virtual, network-based KTIs enjoy neither permanent physical or digital space; similar to virtual scientific communities and only exist as peer-to-peer connections within a network (Allen and Taylor, 2005; Mahr and Lievens, 2012). This provides the context for our study. Cahoy et al. (2020, p. 308) explicitly state "*The potential for non-traditional mechanisms to facilitate technology transfer has grown dramatically over time and will continue to progress with the assistance of new software and systems… By analyzing the attributes of successful methods as well as paying close attention to the current needs of industry, we will likely see a more important role for alternate transfer systems as a supplement to the standard bilateral transaction*." With the global COVID-19 pandemic pushing digitalisation across all the organizations, studying digital forms of organizing that support collaboration for innovation and understanding the differences of the novel forms from traditional ones appears particularly timely (Priyono and Moin, 2020; Seetharaman, 2020).

The fundamental contribution of our study is the derivation of a theoretical, analytical frame that enables us to contrast traditional university-industry knowledge transfer intermediaries with KTIs that occupy only a virtual presence or that are emerging digitally-enabled platforms. This is important; firstly, as the context for intermediation becomes more complex, KTIs need to understand the benefits of new models and modes of operation. Secondly, in terms of successful knowledge transfer intermediation, Alpaydin and Fitjar (2021) affirm and stress the importance of proximities (cognitive, social, institutional and geographical). Understanding how these proximities manifest (traditional, digital, virtual) is important in an era of massive virtualisation and digitalization (Cahoy, 2020). This also raises implications for science, technology and innovation policy in how publicly funded KTI should be structured given these emerging KTI models. Despite current research efforts, a theoretical frame explaining the distinction between traditional and emerging knowledge transfer intermediaries in the university-industry collaboration context is missing (Cahoy, 2020; Fai et al., 2018; Hayter et al., 2020).

It is important to note, intermediation is a social phenomenon (Ren et al., 2019), representing the interaction between social actors occurring across various organisational contexts. Accordingly, adopting interdisciplinary approaches, the structure and agency debate from social science may help us further understand the variety of knowledge transfer intermediaries, which so far is framed mainly in management science (Bellandi et al., 2021; Vorley and Nelles, 2009).

Thus we explore structures, modes of operation and action, anchored in the theory of institutional logics, by exercising the classical tensions of structure vs. agency (Archer, 2004, 1995). The interplay between hard organisational structures, processes or rules and the flexibility, autonomy and agency offered by human agents (Archer, 1995), determines how institutions shape the rules for actions or actions shape institutions (Kukk et al., 2016). For the purposes of this study, we use the definition of structure and agency from the works of Archer (1995 and 2004); where the structure is seen as patterned arrangements limiting the opportunities and choices of intermediary organizations, while agency represents intermediaries' ability to act independently and make free choices. Furthermore, in considering agency we also drew on the work Emirbayer and Mische (1998) who argue that agency is shaped by the past, is future-orientated and grounded in the present through a process of social engagement. Bandura (2006, p. 164) argues that: '*People create social systems, and these systems, in turn, organize and influence people's lives.*' Thus, two principal research questions guide us: ***(1) how are the KTIs structured, concerning their host institutions*** (the *structural* dimension)***?*** *and* ***(2) what do they do*** (the *agency* dimension)***?***

Our conclusions, derived by applying our analytical framework to compare university-industry knowledge transfer intermediation, indicate that whilst traditional KTIs are extending their value chain, as noted in recent studies (Hayter et al., 2020), virtual and digitally-platform enabled KTIs are more selective in their offerings. This selectivity alone, however, did not lead to agility, as agility comes with the ability to create operational conditions enabling a culture of open and unbounded decision making. We also conclude that parent or host institution relationships influence, even unconsciously, the agency and cognitive regime of the KTIs regardless of their digital, virtual or traditional nature.

These conclusions contribute to ongoing research in innovation management field on understanding knowledge transfer organizations – their traditional and emerging forms – via extending the field towards a conceptual instrumentarium from social and organizational studies (Koumakhov and Daoud, 2020; Tomer, 1990; Whittincton, 1988). They also create pertinent and practical recommendations for university managers and KTI entrepreneurs accordingly.

2. University-industry knowledge transfer intermediaries: an organizational perspective

Historically university-industry interaction varies significantly across geographies, cultures and contexts (Decter et al., 2007; Ramirez, 2002), with varied research perspectives studying numerous issues and challenges (Bruneel et al., 2010; Galán-Muros and Plewa, 2016), the most pertinent we review below.

2.1. Intermediaries formalizing university-industry knowledge transfer

The 1980, Bayh-Dole Act put IP related trading and technology transfer at the forefront of US higher education policy (Mowery and Sampat, 2004). European institutions soon followed, with extensive networks of Technology Transfer Offices (TTOs) springing up, initially at technical institutions. The relationship between research-driven knowledge and its transfer and impact, however, was far less straightforward (Gibson et al., 2019; Ilker Ar M., Temel, S., Dabic, M., Howells, J., Mert, A., & Yesilay, 2021). Some empirical studies highlight that TTOs performance is dependent on their resources, the human capital of scientists and organisational factors (Lafuente and Berbegal-Mirabent, 2019; Siegel et al., 2003), but suggest the role of TTOs is marginal when it comes to new venture creation (Clarysse et al., 2011). Landmark reviews in the UK such as Lambert (Lambert, 2003), the EU (Holi et al., 2008) and in Australia (Howard, 2005) reinforced wider constructs of knowledge as essential to complement technology. That has led to nomenclature shifts and practice revision toward knowledge transfer; with the latest positioning knowledge exchange as a two-directional sharing activity enabled by Knowledge Transfer Offices (KTOs) (Kitson, 2009) and Technology Transfer Offices (TTOs) (Cunningham et al., 2020). Ongoing debates still exist relating to the mission and focus of KTOs & TTOs, given the range of knowledge transfer activities and the stakeholders they interact with (Compagnucci and Spigarelli, 2020; Fitzgerald and Cunningham, 2016; Siegel et al., 2003), but many authors now combine these roles as knowledge transfer intermediation.

Extant studies apply numerous research perspectives to university-industry KTIs and in summary, there are three main schools of thought. First, a 'channel theory' approach, compares informal vs.

formal knowledge sharing and focuses on transferring different types of knowledge (tacit vs. explicit) to enhance knowledge transfer performance (Alexander et al., 2018; Alexander and Martin, 2013; Maria et al., 2013). Second, 'entrepreneurial university thinking' (Etzkowitz, 2003; Guerrero et al., 2015, 2014) identifies types of institutions; types of academic and particularly institutional governance approaches that are particularly important for knowledge transfer (Miller et al., 2018). A third school-of-thought suggests local, regional and national structuring of KTIs can establish demand-led strategies for knowledge transfer, where industry partners work collaboratively in university-industry networks, enabling industrial articulation of the specific knowledge they require (Cunningham et al., 2020; Landry et al., 2013; Rodriguez, 2010; Schoen et al., 2014). The second and third schools of thought anchor our paper: where shifting political contexts, increased national economic imperatives, and increased competition between institutions have led to the emergence of various structural models of university-industry knowledge intermediation. In particular, we compare traditional, virtual network-based and digital intermediation platforms (Søndergaard et al., 2015).

KTIs aim to fix the knowledge-capability disconnect and align stakeholders toward common goals (akin to business-to-business intermediation) via: knowledge diffusion, adoption and technology transfer; innovation management; building and bridging innovation systems and networks and supporting localised, industrial change management (Howells, 2006). The recent emergence of virtual, network models of intermediation and platform-based knowledge transfer intermediaries (enabled by new digital technologies) are extending the search range, decreasing the participation cost for each partner and assisting in making tacit knowledge more codified – thus enabling knowledge transactions on the go (Cahoy, 2021; Dushnitsky and Klueter, 2017; Lee, 2021). However virtual and digital forms of KTIs represent a novel, emerging phenomena remaining largely unstudied (Cahoy, 2020). Existing literature further fails to estimate the scale of the phenomena although massive digitalization, partially driven by the Covid-19 pandemic, has called for studies on these forms of knowledge transfer intermediation (Jussila et al., 2021). Our research enables gradual steps towards understanding the emerging KTIs, through comparison to traditional KTIs.

Due to their complex nature, these contemporary models of knowledge transfer intermediation could be studied from multiple perspectives [economics, sociology, management and computer science according to Holzmann et al., (2014)] . This amplifies the challenge of comparing virtual and digital models with traditional KTIs. Likewise, a range of theoretical lenses could be used to explore the activities of KTIs, however, the most recent findings on knowledge transfer intermediaries point out to the novel KTIs' structures and courses of action as well as call for further research on those (Baglieri et al., 2018; Cahoy, 2021). Thus, anchoring our study in the discipline of management, to address our posited research questions, we select classical structural theory.

2.2. Institutional logics and university-to-business knowledge transfer intermediaries

One approach, proposed by researchers, for understanding persistence, diffusion, and change in organisations is institutional logic, relating "*socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organise time and space, and provide meaning to their social reality*" (Thornton and Ocasio, 1999). Thornton, et al. (2012) go on to argue '*institutional logics is a meta-theoretical framework for analysing the interrelationships among institutions, individuals and organisations in social systems'*. Providing links between institutional structure and individual action, institutional logic bridges macro-social structures and micro-level behaviour (Thornton and Ocasio, 2005).

Institutional logic is embedded in 'organising principles' that describe the goals and the values of the institution and govern action (Friedland and Alford, 1991), which in turn facilitate organisational coordination toward prescribed aims, and enable "*interdependence among individuals, units, and activities in the face of behavioural uncertainty*" (McEvily et al., 2003). In a given social domain, underlying logic unifies diverse activities and interests, such that competing institutional logics can and do co-exist, which is reflected by the concept of a 'hybrid organization' (Pache and Santos, 2011; Perkmann et al., 2019; Reay and Hinings, 2009). KTIs are hybrid organisations, due to their intermediation role aiming to align diverse stakeholder requirements in complex contexts (such as knowledge and technology transfer). Thus, comprehending the emergence and contestation of new organising principles within institutional logics is fundamental to our understanding of the micro-foundations of institutional persistence and change (Townley, 2002). By engaging institutionally embedded individuals with shared goals, values, and beliefs upon which social cooperation may be based, organising principles facilitate the emergence of trust, as these shared principles provide a basis for predicting the probable future actions of other stakeholders (Sonpar et al., 2009). Trust is identified as an essential component in knowledge transfer (Alexander and Childe, 2013), requiring actors to plan and control their actions (which can originate in institutional logics or relate more to embedded cultural identity within the individual) creating tension between structure and agency as identified by (Archer, 1995). This is hugely problematic in the complex context of inter-institutional intermediation.

Compounding this complexity, intra-organisational complexities exist in the university domain, particularly those arising from contradictory research ethos between curiosity-driven research and the rise of the 'impact agenda', or the parallel clash of logics within an 'entrepreneurial university' (Etzkowitz, 1998; Perkmann et al., 2019). Scientists involved in university-industry collaborations create tensions at the micro-level (see (Mangematin et al., 2014). The fundamental institutional logic of TTOs was to build and support the legitimacy for technology and knowledge discovery (Jain and George, 2007). With contemporary progression to the transfer, adoption and exploitation of knowledge in knowledge transfer intermediation, both engaging structure and agent dis-alignment in the formulation of strategies/operations to satisfy diverse stakeholders (Alexander et al., 2018). In their study of US, Ireland and New Zealand contexts, O'Kane et al., (2015) conclude that progressive TTOs need to carve out a distinct identity that appeals to both internal and external stakeholders, which legitimizes their existence and activities. Furthermore, O'Kane et al., (2020) posit that TTO executives play a central brokering role within innovation and entrepreneurship ecosystems alongside their university-industry intermediary role. Studies have also highlighted the importance of university-industry collaboration in supporting innovation outcomes for firms and industries (Petruzzelli and Gianluca, 2020) and supporting SMEs (Petruzzelli and Murgia, 2021). Regardless of their organisational logic, for KTIs to be successful they must adopt a knowledge integration strategy, whilst paying attention to developing their internal organizational capabilities (Bercovitz et al., 2001).

Summing up: knowledge transfer intermediaries, bridging universities and industry, must hybridise underlying institutional logics, blending their activity for organisational specificity. Perkmann et al., (2019) distinguish between two types of institutional complexity solutions: blended hybrids (where logics combine); and structural hybrids (where different logics dominate different departments). Blended hybrids have been extensively studied, but structural hybrids remain unexplored (ibid).

Existing literature also suggests university-industry KTIs can operate in various forms: from traditional, physical, campus-based TTO/KTOs; to virtual communities of staff, organised by scientific discipline or regional specialisms (collocated in physical offices or not, on campus, in Innovation Centres and Science Parks or remote-working based); or hosted entirely on permanent digital spaces and platforms (with no anchoring location or institutional alignment) (Alexander and Miller,

2017; Dushnitsky and Klueter, 2017; Mahr and Lievens, 2012; O'Kane et al., 2015). Across this range from university-based, physical entities (Muscio, 2010), to scientists-driven virtual communities (Mahr and Lievens, 2012) and commercial digital platforms (Dushnitsky and Klueter, 2017), the spectrum of structural hybrids creates competing institutional logics. We, therefore, explore our sample group through the structure versus agency prism, where structure tackles the scaffolded interplay between the institutional and organizational theories (Zilber, 2012) while agency invites a deep-dive into contextualised action, but first, we must anchor these concepts into further literature from the university-industry collaboration context.

2.3. Intermediating university to business knowledge transfer: the structure and agency dimensions

Reviewing KTI-focussed literature we identify several KTIs characteristics, to address our research question '***how are the KTIs structured, concerning their host institutions*** (the *structural* dimension)'. We organize the literature-based characteristics into three high-level structural sub-streams: *knowledge strategy* (governing the transfer of knowledge), *knowledge asset ownership* (where the ownership of knowledge resides) and *knowledge performance* (which structural entity is responsible for assessing the performance of the knowledge transfer activity). Examining these in more granularity, we identify various literature-driven sub-criteria, summarised in Table 1a that enabled us to create an analytical framework, which aims to assess the structural dimension (see Appendix 1 for a detailed literature grounding).

To address the second element of our RQ, '***what do KTIs do?'*** we construct a further simple classification. Adopting Howells (2006) sub-classifications of innovation intermediaries' functions (that fall into our definition of agency), we reflect on later works, focussed particularly on the university-industry collaboration context (Acworth, 2008; Alexander and Martin, 2013) to present sub-categorisations (summarised in Table 1b and see Appendix 1 for background literature).

In summary, the structure and functions of KTIs are widely explored and understood, however, most of the existing studies rely on traditional, physical KTIs (Arqué-Castells et al., 2016; Conti and Gaule, 2011), while emerging virtual communities, online knowledge marketplaces, crowdsourcing platforms and digital knowledge transfer intermediaries – remain largely unexplored, both in the business-to-business context (Dushnitsky and Klueter, 2017) and even more in university-to-business context (Barlatier et al., 2017; Søndergaard et al., 2015). As Hayter et al., (2020) put it: "*Now would also seem to be a good time to write about entirely new pathways involving the use of digital platforms (social media), open access (also to data and platforms), etc.*" We, therefore, use the lens of structure and agency to explore a sample of KTIs from across the spectrum of knowledge transfer in the university-industry collaboration context. Thus, we aim to not only develop new insights on the digital forms of intermediaries alone, but also compare and link to the existing knowledge on traditional, physical university-industry KTIs.

3. Methodology

3.1. Approach and sampling

Our study is exploratory and focuses on the heavily contextualised nature of intermediation in university-industry collaboration, thus we took an inductive and qualitative approach. We applied a context-rich, multiple case study method (Eisenhardt, 1989; Stake, 2006; Yin, 2011), set within an interpretivist, 'critical pragmatism' paradigm, which allows us to combine interpretation, lived experience, and integrating multi-stakeholder perspectives. This contrast to a purely positivistic approach, that requires a greater focus on objective empirical data testing and more relevant theory than the current literature poses (Georgeson and Maslin, 2018; Kadlec, 2006; Midtgarden, 2012). This approach allows open-ended and flexible inquiry, aimed at achieving a greater understanding of a novel phenomenon (virtual and digital platform KTIs) contrast against more established models (of physical KTIs) (Georgeson and Maslin, 2018; Kadlec, 2006). Contextual richness calls for a maximum variation sampling strategy (Patton, 1990), aiming to capture university-industry KTIs with diverse characteristics; thus locus of action for a physical (traditional), virtual or digital location denoted our initial selection criteria. We also target diversity in terms of the KTIs institutional setting (contrasting geographic location, age and ownership type) presenting 20 KTIs who offered their data (see Table 2). Following qualitative data saturation protocol (Fusch and Ness, 2015; Guest et al., 2006), we achieve data saturation across our sample group,

Table 1a
– A Structural lens for analysing KTIs

KTI dimensions		#	KTI Characteristics	Illustrative Authors, Studies and Interpretation	Categories
STRUCTURE	I. K. Strategy	1	Location of activity	Alexander & Martin, 2013: extent of face-to-face interaction and media richness - Murray & Peyrefitte, 2007; Ardito et al., 2018	Physical vs. Virtual
		2	Perimeter: focus of value-added activities	Schoen et al., 2014: degree of exclusivity; Secundo, 2017	Exclusive vs. Non-Exclusive
		3	Perimeter: definition of operational location	Schoen et al., 2014: definition of boundaries/activity Kreiling & Scanlan, 2020	Local / Regional / National / Cloud
		4	Discipline: sector focus	Schoen et al 2014: degree of discipline specialization Secundo, 2017	Sector Focus vs. No Focus
		5	Proximity to knowledge source	Alexander & Martin, 2013: geographic proximity; Messeni Petruzzelli & Murgia 2021; Petruzzelli, 2011	In-House/Arms-Length /Independent
		6	Locus of governance	Schoen et al 2014: level of autonomy; Markman et al., 2005: traditional, non-profit, and for-profit	Prescribed / Semi / Autonomous
	II. K. Asset ownership	7	Staff – who pays their salary	Jensen et al., 2003; Siegel et al., 2003: salary vs. "making deals", Cunningham et al., 2020	Knowledge Source/ Govt / Revenue Income
		8	Facilities	Barlatier, 2017; Kochenkova et al., 2016; Finne et al., 2009; Bozeman, 2000: facilities location, characteristics and ownership	Knowledge Source /Govt / Independent
		9	Financial Resources	Source of start-up/operational funds (Siegel et al., 2003; Mian, 1996; Bonaccorsi et al., 2021)	Knowledge Source / Govt / Shareholders
		10	Background IP	Owen-Smith and Powell, 2001; Liu, 2010, Haan et al., 2020, Lie, 2020: IP ownership	Knowledge Creator / KTI
		11	Foreground IP	Liu, 2010, Lie, 2020: IP ownership	Knowledge Creator / KTI
	III. K. Performance	12	Ownership of Revenue Income	Friedman & Silberman, 2003: revenue Sharing Cunningham et al., 2020	Knowledge Creator / Shared / KTI
		13	Ownership of Metrics	Schoen et al., 2014 'reporting obligations'; Choudhry and Ponzio, 2020	Knowledge Creator / KTI
		14	Unit of Performance & Reporting	Schoen et al., 2014 'reporting obligations' Kreiling & Scanlan, 2020	Knowledge Creator / KTI / Other

Table 1b
– Agency lens for analysing KTIs

AGENCY	IV. KT Activities: what do KTIs do?	15	Foresight and diagnostics	Howells (2006): (a) Technology foresight and forecasting (b) Articulation of needs and requirements. (Agogu et al. 2013; Yusuf 2008; Rossi et al., 2021)	Undertaken / Not Undertaken
		16	Scanning and information processing	Howells (2006): (a) Scanning and technology intelligence (Petruzzelli and Rotolo, 2015) (b) Scoping and filtering; (Dushnitsky & Klueter 2017; Perkmann et al., 2013)	Undertaken / Partial / Not Undertaken
		17	Knowledge processing, generation and combination	Howells (2006): (a) Combinatorial (b) Generation and recombination. Barlatier (2017): tacit knowledge is never transferred (duplicated identically), but it is always recreated by the receiver (Knowledge Disseminator takes part in Knowledge Creation). Sub-divisions of creation, dissemination, diffusion, adoption and capitalisation (Miller et al, 2016)	Creation/ Dissemination / Diffusion / Adoption / Capitalisation
		18	Gatekeeping and brokering: Network building	Howells (2006): (a) Matchmaking and brokering; (Cranefield & Yoong 2007); Brokering (O'Kane et al., 2020); Network building (Agogu et al., 2013; Dushnitsky and Klueter, 2017)	Undertaken / Partial / Not Undertaken
		19	Gatekeeping and brokering: Contracts	Howells (2006): (b) Contractual advice. Schoen et al., 2014: 2) degree of task specialization: Research funding services ("contract negotiation")	Issuer / User
		20	Crowdsourcing	Barlatier (2017); Howells (2006); (Baglieri et al., 2018; Schenk et al., 2019)	Instigator / Referrer / Not Undertaken
		21	Testing, validation and training	Bolzani et al. (2021), Howells (2006), Silva and Ramos (2021): (a) Testing, diagnostics, analysis and inspection (b) Prototyping and pilot facilities (c) Scale-up (d) Validation (e) Training	Undertaken / Partial / Not Undertaken
		22	Accreditation and standards	Howells (2006); Cahoy, 2021: (a) Specification setter or providing standards advice (b) Formal standards-setting and verification (c) Voluntary and de facto standards setter	Issuer / Contributor / Not Undertaken
	V. How are the activities regulated?	23	Process of governance: Regulation and arbitration (Dispute resolution)	Howells (2006); Sutopo et al. (2019): (a) Regulation (b) Self-regulation (c) Informal regulation and arbitration. Contreras and Rinekardt (2020) Conflicts of research.	Leader / Referrer / Not Undertaken
		24	IP management	Schoen et al 2014; Cahoy, 2021: degree of task specialization: IP-management. Howells 2006: (a) IP rights advice (b) IP management for clients. Holgersson and Aaboen, (2019)	Undertaken / Partial / Not Undertaken
		25	Commercialisation: exploiting the outcomes	Baglieri et al., 2018; Schoen et al 2014: degree of task specialization: Spinout services. Howells (2006): (a) Marketing, support and planning (b) Sales network and selling (c) Finding potential capital funding and organising funding or offerings (d) VC (e) IPO. Fitzgerald et al., (2021)	Undertaken / Partial / Not Undertaken
		26	Assessment and evaluation	Howells (2006): (a) Technology assessment (b) technology evaluation; Lafuente and Berbegal-Mirabent (2019) peer benchmarking	Undertaken / Partial / Not Undertaken

contrasting physical and non-physical intermediaries, before categorising against 'in-house, arm-length and external' intermediaries (Alexander and Miller, 2017; Wright et al., 2008b). We then apply criterion-based sampling logic (Patton, 1990) to extend theory-based categorisation to include virtual and digital intermediation forms. Basic meta themes and initial comparison saturation was achieved at 16 cases. The additional 4 cases' data collected only supported the earlier derived themes without changing the codebook, and thus we retained 20 cases as our sample.

3.2. Data collection

The data collection was carried out during 2014-2020 via telephone and semi-structured follow-up surveys, as well as personal interviews with the KTIs staff, KTI clients and a small number of participant observations. The data collection consisted of two phases. The first phase was a short baseline survey undertaken in 2014-2015, which focused on the relative offerings and modes of operation of knowledge transfer organisations from 12 respondent institutions globally – including both technology transfer offices having physical spaces and intellectual communities of scholars existing only in a virtual space – neither having any physical space or any permanent digital home.

The second phase focused on 8 digital platforms (utilising web-based instruments) and exploring these via semi-structured interviews, undertaken in 2015-2020, whilst revisiting, confirming and contrasting content from physical intermediaries from Phase 1. Secondary sources as KTIs webpages, public reports on KTIs performance, dissemination materials shared with us, feedbacks/references on KTIs work and publications on the studied cases also enriched our data.

3.3. Data analysis

Data analysis included two stages: manual coding and software-enabled cluster analysis using Multiple Correspondence Analysis (MCA).

3.3.1. Manual data analysis and inter-rater reliability

The data set was first analysed using categorization, manual text-mining and particularly, template analysis – following the pro-forma of structure and agency characteristics as described in the literature review (Tables 1a and 1b). The cross-case comparison also followed this pro-forma. To assure reliability and validity the data was initially coded by two researchers independently and coding disagreements were discussed to reach consensus. Whenever disagreements or lack of certainty remained, a third co-author was engaged in coding and data interpretation. Furthermore, whenever additional questions emerged during the analysis, we validated our research logic and findings by contacting the respondents and clarifying information to confirm our results.

The data coding required inter-rater reliability checks at two stages. First, we needed to reach an agreement on a coding pro-forma/template (Tables 1a,b). Although this is a literature-driven pro-forma, an agreement on aggregating was still required. Five characteristics were discussed in two rounds of augmentation by two coders, including: locus of governance, background/foreground IP split, performance metrics/unit of reporting split, knowledge processing/generation/recombination merged, crowdsourcing added based on the empirical evidence. Following suggestions by McAlister et al., (2017), based on Miles et al.,

Table 2
Case Study University-Industry KTIs.

KTI Code	KTI Main Office Location	KTI Age:Young (Up to 4 years old); Established (4-7 years); Mature (7 years or older)	Organizational Ownership Public / Private Organization
KTI 1	Australia	Established	Private
KTI 2	UK	Mature	Public
KTI 3	Australia	Mature	Private
KTI 4	UK	Mature	Private
KTI 5	New Zealand	Established	Public
KTI 6	Norway	Mature	Public
KTI 7	UK	Mature	Private
KTI 8	UK	Young	Private
KTI 9	France	Mature	Public
KTI 10	Germany	Mature	Public
KTI 11	Germany	Mature	Public
KTI 12	Australia	Young	Private
KTI 13	UK	Established	Private
KTI 14	UK	Young	Public
KTI 15	USA	Young	Private
KTI 16	UK	Young	Private
KTI 17	UK	Established	Private
KTI 18	Belgium	Established	Private
KTI 19	Spain	Young	Private
KTI 20	Ireland	Established	Public

(1994), the inter-rater reliability rate (IRR) is the number of agreements divided by the sum of agreements and disagreements, which corresponds to 21/26=0.808 or 80.8% in our case. All the disagreements were solved through the course of discussions and cross-checks of the data and the literature. The second stage of inter-rater reliability checks included all codes from 20 cases against 26 characteristics from the pro-forma. See Table 3 for the qualitative coding illustrative extract.

Despite a precise proforma, a few dissagrements remained, particularly about 26 elements: perimeter – distinguishing 3 KTIs as regional/cloud took extensive discussion; semi-prescribed locus of governance in 2 KTIs and partial scanning and information processing in 7 KTIs was distinguished after a few coding rounds; foresight and diagnostics as an undertaken activity in 4 KTIs required additional clarifications; the full scale of knowledge processing activities was examined additionally in 4 KTIs based on the doubts of one co-author; crowdsourcing activity was analysed deeper in 2 cases to confirm its presence; undertaking testing/validation/training and commercialization activities in 2 KTIs required additional data enquires and subsequent coding. Accordingly, the IRR for the second data analysis stage is: ((20*26codes)-26 disagreements) [agreements] / (((20*26)-26) agreements+26 disagreements)= 494/520=0.95 or 95%. Such a high agreement rate was also achieved through clarifying the disagrements at the pro-forma stage and continuous cross-checks between the theory-driven pro-forma and empirical data. As mentioned, the disagrements at the second stage were solved through discussions, additional clarifying data collected and introduction of new or unification of the subcategories.

3.3.2. *Cluster analysis with multiple correspondence analysis*

Manual data analysis allowed us to sense the categories of the KTIs (traditional, regional-cluster, virtual community, digital KTIs – see Table 6 in the Findings section), but with data inconsistencies, some KTIs did not fit a single proposed category. To resolve these issues we adopted a detailed cluster analysis, enabling clearer distinctions between groups of KTI data based on our common characteristics. Cluster analysis is a rigorous way to understand what additional dimensions our data could illuminate beyond the literature-driven manual and subjective (potentially somewhat misleading) manual categorization. Given our data consists of qualitative, categorical variables instead of numerical, we adopted Multiple Correspondence Analysis (MCA) (Abdi and Valentin, 2007). Furthermore, MCA enables multidimensional scaling (Hoffman and De Leeuw, 1992) which allowed us to determine if another dimension could help differentiate our sample KTIs, beyond our literature-driven structure/agency divide.

Our MCA relied on particularly FactorMineR package in R software, which allowed us to calculate eigenvalues/variances retained by calculated dimensions to characterise our KTIs. Initially aiming at greater variance we ran MCA for 20 possible dimensions, before realising 15 dimensions cover all possible sample variations, and where our first two dimensions explain up to 52.14 % of the variation in our data (see Appendix 2 for the scree plot). The clusters formed by the two dimensions are shown in Figure 1 and interpreted in the results section 4.3. Categories that shape the two dimensions and their eigenvalues are shown in Appendix 3. Correlation between the variables (KTIs characteristics) and the two principal dimensions resulting from the MCA is illustrated by the matrix in Appendix 4. Further interpretations and analysis follow in section 4.3.

4. Findings

Applying our literature-driven framework (see Tables 1a & 1b), to categorise our KTI sample against the structure vs. agency dimension (see Tables 4 & 5), we first manually interpret the data and distinguish between physical, regional-cloud, virtual and digital forms (summarized in Table 6). Table 6 reflects our initial interpretations, the perceptions that all co-authors agreed on at the first waves of coding rounds and reflections on how the studied KTIs principally differ. That enabled an initial categorization of where and how university-industry KTIs operate. This also allowed us to spot any inconsistencies of these types and to further our analysis we run a cluster analysis (See section 4.3). However, to better explain the data itself we first follow with our preliminary manually performed data observations.

4.1. *The Structure Dimension of KTIs*

We found a variety of ways in which the studied knowledge transfer intermediaries differ in regards to their structures. Namely, their operations' location distributes across physical (KTIs 1-8, 10, 11) and digital (KTIs 9, 12-20) KTIs, with KTI20 engaging both forms of operations location – while having a physical office KTI20 also has a digital platform "*aggregating all Irish universities research to one place*". Similarly, this corresponds with their degrees of exclusivity – most of the KTIs that have a physical operation location exclusively serve a single university (except for KTIs 9-12) – see Table 4. This suggests KTIs with a dominant physical location tend to be bound to a single organisation, while the digital model serves multiple organisations. That is well illustrated by the legal ownership: KTIs 1-3 and 7 have arms-length relationships with their host, whereas others (4-6, 8, 9 & 12) are fully in-house and owned. The remainder KTIs (10, 11 and 13-20) are classified independent. KTIs with a physical, structurally governed presence also predominantly focus on their immediate perimeter for their services, except for KTIs 3 and 9, both from Australia.

KTI9 extends its perimeter to the region, whereas KTI3 interestingly combines having a physical location with operations in the cloud, which is a prerogative of digital KTIs. That makes the classification of a KTI3 problematic and keeps it in between physical and digital KTIs (Table 6). Spotting such inconsistencies in our manual data analysis inclined us to additionally run cluster analysis, which helped to characterize KTIs more systematically, as well as confirmed KTI3, being somewhat an

Table 3
Qualitative Coding Illustrative Extract.

First-order codes/original quotes	Second-order codes	Theory-driven matching categories	Aggregated categories	Aggregated theory-driven categories (Structure vs. agency)
"*We supervise the collaboration digitally.*" (KTI19)	Virtual	Location of activity	Knowledge Strategy	Structure
"*The only way that a company can get exclusive rights is to buy the intellectual property. They have a time-frame of six months, after the end of the competition, to decide to do so. In that time there's a non-disclosure period, so it means the student needs to keep the intellectual property confidential… If the company in that period says that they want the intellectual property, then the student must deliver it. They get paid for that also, of course*". (KTI18)	Knowledge Creator	Foreground IP	Knowledge Asset Ownership	Structure
"*We have rewritten consulting contracts, dealing with IP ownership etc. We own the background IP, clients own the project IP, unless it is an improvement to our background IP, in which case we need it for commercial activity*" (KTI1)	KTI	Foreground IP	Knowledge Asset Ownership	Structure
"*They don't need to play by the university rules, separate, so they can have their own rules. Uniservices gets assigned the IP, and all contract research goes through them. Freedom to operate with University's best interests at heart.*"(KTI5)	Knowledge Creator	Ownership of Revenue Income	Knowledge Performance	Structure
"*So the corporates pay us to find innovations, and the platform is the sort of, the centre, the hub of how that works. So why we can offer this for free for universities is the corporates pay us to find things.*" (KTI17)	Shared	Ownership of Revenue Income	Knowledge Performance	Structure
"*We have submitted a number of tenders as the VUIMN and are able to leverage the skill set to meet requirements. We could not do this independently as resourcing is an issue.*"(KTI12)	Undertaken Creation, Dissemination, Diffusion	Knowledge processing, generation & combination	KTI activities	Agency
'*So, we take briefs from universities. They can range from technology readiness levels zero through nine... and then the actual opportunity that's being sought, whether it's the licensing… or…, we then take those projects and using our own network of, executives in strategic positions within industry, we'll target them and say, hey John… this opportunity has just come on and we think it would be a great fit for your team, what do you think. Because we've automated that whole process and we have a very personalised touch to it… we're able to then get John to come back and say, yeah that sounds great…. then us getting back in contact with the university… please get in touch… and then we step out of the conversation completely.*" (KTI13)	Undertaken Dissemination, Diffusion, Adoption	Scanning & info. processing Knowledge processing, generation & combination	KTI activities	Agency
'*… [We] collect all the feedback we receive from industry…, it can range from "this technology looks too early stage"… all the way to "this does look interesting but we tried it before and it didn't work, have a look at these data", so the university technology transfer teams we've been working with, they've been really appreciating that kind of feedback to be able to go back to their universities and say, hey, we're not experts but these guys are in the industry and they say this is what you should be doing.*' (KTI 13)	Not Undertaken	Assessment & evaluation	Activities regulation	Agency

outlier – see section 4.3. However, one category where these are consistent is the sectoral focus, where 14 of our KTIs (1, 2, 4-8, 12-15, 17, 19 & 20) have a pan sectoral focus, whereas 6 (KTIs 3, 9, 10, 11, 16 & 18) adopt a sectoral focus to their activities.

Linked to the operations' location of the KTIs 1-8 being predominantly physical, their host institution owns their facilities, pays staff salaries, and requires a locus of governance, aligning these with the KTIs' services provided exclusively to the host. KTIs 9 & 12 mirror much of the physical KTIs' group structure, but interestingly they present as virtual organisations. In line with the definition of the virtual organization by Mowshowitz (1997), KTIs 9 and 12 are goal-oriented (knowledge and technology transfer oriented) entities under the meta management (of different research experts). However, although KTIs 9 and 12 are virtual (not having operational physical space), they do not have any permanent digital (platform) space either and their operations are entirely 'hanging' in virtual communications between their members. In contrast, KTIs 13-20 operate virtually, but have a permanent digital "home", a web-based digital platform, which distinguishes them from physical KTIs 1-8, 10, 11 and virtual KTIs 9 and 12. A further distinction between the studied KTIs on the physical/digital spectrum is illustrated in Table 6. Digital, platform-based KTIs 13 and 15-19 rely on revenue income to fund salaries, facilities and use shareholder capital to create financial resources. KTIs 14 & 20, although having a digital presence, draw funds from the state to pay staff, facilities, and fund development accordingly, but they also receive prescribed levels of governance (which we assume follows the funding).

Stifling agency, KTIs 1, 2 and 4-8 have performance metrics prescribed, with requirements for reporting performance, whereas KTIs 3, 11-20 (who are not physically tied, nor exclusive) take ownership of their performance metrics and reporting cycles accordingly. Structurally tied KTIs (1-10) also enjoy little flexibility in owning or sharing background and foreground IP, with host as knowledge creators controlling all IP. Structurally independent digital KTIs (13-20), in turn, are administratively so distant from their multiple clients, that ownership of IP unquestionably belongs to the knowledge creators (either a university, a university employee, a student or firm or both sides): "*So, by default, if the company does not decide to buy the intellectual property, which they can do at the end, the student keeps the intellectual property*" (KTI 18). The two German KTIs (11&12), in turn, vest IP ownership in their KTIs, which enables them to trade IP relatively autonomously. Before we analyse the nature of the structural differences between KTIs with the cluster analysis, we first observe the agency trends.

4.2. The Agency Dimension of KTIs

The agency dimension helps us to understand which intermediary

functions our KTIs undertook, as well as how do they differ from each other in their agency (See Table 5).

In terms of *foresight and diagnostics*, this function is generally not undertaken, with exception of the German KTIs 10 and 11, who run foresight and diagnosis at the outset of their projects, however, ten KTIs do provide *scanning and information processing* at least partially (KTIs 3, 6, 9, 10, 11, 13, 14-20) as a co-founder of the KTI 13 notes: *"We're currently monetising our industry audience in terms of alerts and strategic updates, trending*". This suggests scoping and forecasting is useful but full foresight and market diagnosis are not seen as part of the common roles of a KTI, regardless of their structure or agency bias. In offering knowledge services KTIs 1, 2, 4-8, 11 & 18 provide the widest spectrum, including creation, dissemination, diffusion, adoption and capitalisation, the most limited being KTIs 12, 14, 15 & 20 that only undertake knowledge dissemination and diffusion.

KTIs 9, 13, 16 & 17 use knowledge adoption to compliment dissemination and diffusion as stated by a co-founder of the KTI 17: "*Let's assume the university has 20 innovations on the platform… We can send them the details… so they know which innovations are being opened and which ones aren't. Then they need to ask themselves the question why… why a lot of people [are] opening the innovation A and very few opening innovation M*". A discernible trend exists, with group 1 – 11 undertaking more of the spectrum of knowledge transfer and the KTIs 12-20 choosing to undertake less. This may be reinforced by their funding models and

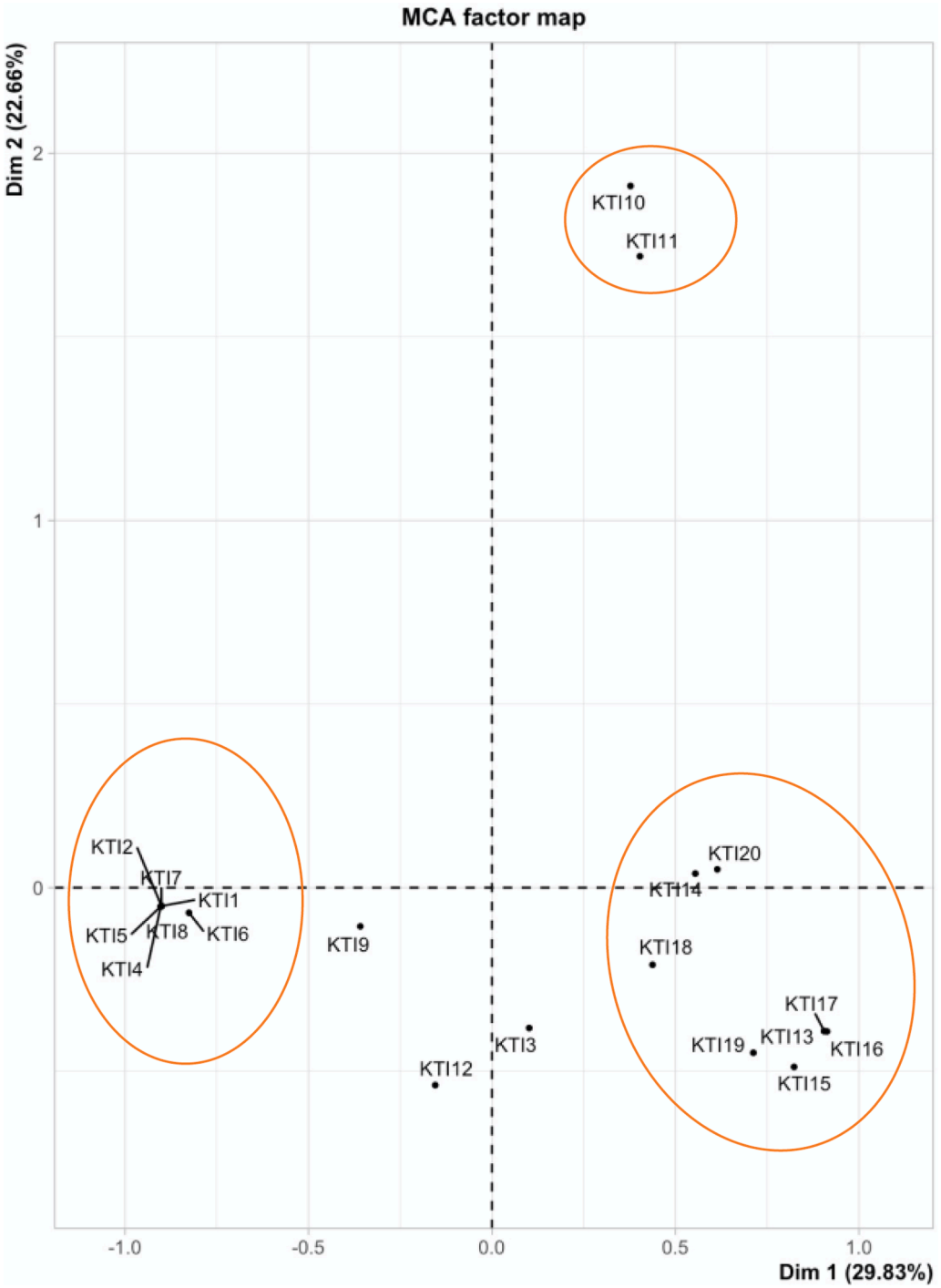

Figure 1. – Factor analysis plot – clusters of the KTIs

their governance – the owned KTIs required to cover a wider spectrum, and autonomy creating more focussed offerings.

Softer offerings akin to knowledge exchange, *gatekeeper activities and networking activities* are offered partially by 15, 18 & 20, the remaining 17 KTIs offering those entirely. For *contracting*, (a less soft offering) a more noticeable split is evident, accord to our structural grouping, where KTIs 1-12 generally act as *issuers of contracts* (except 3 & 9) but with wider variance in the grouping 13-20 – with 18 &19 issuing contracts and the remainder *using a third party* to create contracting agreements as noted by a co-founder at KTI 13: "*People within tech transfer teams… their time is better spent working at contracts, negotiating deals with a partner rather than that first bit of finding out who's gonna be interested, so it takes a lot of time and normally it's fruitless, so that's where we operate. We're at the very beginning and we're an introductory service, it's what some people call us well. So not only do we do reporting through impact reports but it's all about the introductions we provide*". For *dispute resolution* of contracts, a similar trend exists, with KTIs 1-12 choosing to *undertake resolution* and KTIs 13-20 either referring this activity to a third party or not undertaking any form of dispute resolution.

Considering *testing, validation and training* and *providing specification and user standards* for created knowledge, our loose groupings are also relatively consistent as KTIs 1-9 undertook partial testing, validation and training, with this fully undertaken by KTI 10 & 11. For KTIs 12-20 (excepting 15, 18 & 19) this was outside of their scope of services, with 15, 18 & 19 offering it partially. In terms of *accreditation and standards,* KTI 1-9 & 18 were contributors only, whereas the remainder took no part, with exception of KTI 10 & 11, who carried out this activity and issued these standards. Once again, we see distinctly different approaches to agent-driven services by the German KTIs.

For *IP management, commercialisation* and *technology assessment and evaluations*, our results were more consistent with our groupings, where KTIs 1-11 all either partially or fully undertook this activity and KTIs 12 – 17 not (with an exception of KTI 14 that partially undertook *commercialisation* in terms of spin-out services only). KTIs 17-20 showed more variance, with KTI 18 undertaking *IP management*, whereas KT19 partial and KT20 not undertaking it. In terms of *exploiting commercialisation opportunities* KTI 17, 18 - 20 did, but in terms of assessing technology potential, KTIs 19 & 20 did not. This suggests autonomy has led them to steer away from IP commercialisation.

One interesting observation we will explore in more detail was *crowdsourcing*, where a distinct hesitation across most KTIs existed, preferring to refer to specialist organisations to undertake this, with the exception of KTIs 18 & 19. To illustrate the exceptions, the respondent from KTI 18 shared his thoughts on their program of facilitating university-industry collaboration, which implies students working on solving companies' challenges as a part of their study program – being both a benefit and a restriction:

> "….*The fact that we only have two cycles each year, which is considered as being not very flexible [is a challenge]. But that is only because they compare us with the classical crowdsourcing programmes where you can start a challenge, at each point in time. My answer to that is that, OK, this might be a disadvantage of our programme, that, I use the metaphor to explain that we are a very high-speed train, but we only have two trips a year. But once they jump in on the train, this [is] actually a very fast and efficient process which is acknowledged by the companies. But unfortunately, the way the programme is designed, we cannot be very flexible in terms of when we can run the (programme)*" (KTI 18)

In Table 6 we present a simplified KTIs typology distinguishing between traditional, regional-cluster, virtual-community and digital KTIs along the structure and agency dimensions. This distinction illustrates an entire spectrum of the existing KTIs and highlights the regional-cluster and virtual-community ones as hybrids or those sitting in between traditional TTOs and emerging digital knowledge transfer intermediaries. Given these loose positions of categories, inconsistencies in this initial categorization and outliers as KTI 3, cluster analysis was run and follows in section 4.3.

We suggest access to a well-developed digital infrastructure and having the capacity to manage the networks of companies and universities is crucial in enabling this activity. However, this is not "the norm" yet, as the traditional, non-digital, form of partnership search has been there for decades, see what the KTI 19' co-founder thinks:

> "*You need as a company… to have digital means to access universities that you haven't worked before and you need to catch the hearts and souls of the students and faculty members that can help you solve challenges and that provide the infrastructure and talent that you so desperately look for as a company to recruit in the future. And I think that, that to some extent didn't get to everyone, so they think they have recruited across the road for the last 40 years and this is the way it's going to be for the next 40 years but this has changed and this will not be the only place to source talent and innovation going forward…*"

Although our data was collected before the massive pandemic digitalisation wave, the need for interconnectivity, and digitalisation of knowledge transfer intermediaries was already sensed by our emerging digital KTIs.

4.3. Cluster analysis results: a bi-dimensional framework

To further understand and explain the differences between various KTIs we turn to the results of the cluster analysis (see Figure 1). Following the two dimensions explaining 52% of the data variation, the MCA distinguishes bi-dimensionally between cluster 1 (KTI 1, 2, 4-8), cluster 2 (KTIs 13-20) and cluster 3 (KTI 11 & 12), with KTIs 3, 9 and 12 seating in between clusters 1 and 2. The first dimension on the matrix (Dim 1) clearly distinguishes cluster 1 from clusters 2 and 3, while the second dimension (Dim 2) is clearly separating KTI 11 and 12 from others according to their distinguishing characteristics. To further understand what determines these dimensions we further reviewed our

Table 4
– Structural dimensions – results of categorization and coding.

KTI dimensions		#	Category	Categorization	KTI1	KTI2	KTI3	KTI4	KTI5	KTI6	KTI7	KTI8	KTI9	KTI10	KTI11	KTI12	KTI13	KTI14	KTI15	KTI16	KTI17	KTI18	KTI19	KTI20
STRUCTURE	I. K. Strategy	1	Location of activity	Physical vs. Virtual	P	P	P	P	P	P	P	P	V	P	P	V	V	V	V	V	V	V	V	P+V
		2	Perimeter: focus of value added activities	Exclusive vs. Non-Exclusive	E	E	E	E	E	E	E	E	E	NE	NE	E	NE	NE	NE	NE	NE	NE	NE	NE
		3	Perimeter: definition of operational location	Local / Regional / National / Cloud	L	L	C	L	L	L	L	L	R	L	L	R	C	N	C	C	C	C	C	N
		4	Discipline: sector focus	Sector Focus vs. No Focus	NF	NF	NF	NF	NF	NF	NF	NF	SF	SF	SF	NF	NF	NF	NF	SF	NF	SF	NF	NF
		5	Proximity to knowledge source	In-House/Arms-Length /Independent	AL	AL	AL	InH	InH	InH	AL	InH	InH	I	I	InH	I	I	I	I	I	I	I	I
		6	Locus of governance	Prescribed / Semi / Autonomous	P	P	S	P	P	P	P	P	P	A	A	S	A	P	A	A	A	A	A	P
	II. K. Asset ownership	7	Staff – who pays their salary	Knowledge Source/ Govt / Revenue Income	KS	KS	KS	KS	KS	KS	KS	KS	KS	G	G	KS	RI	G	RI	RI	RI	RI	RI	G
		8	Facilities	Knowledge Source /Govt / Independent	KS	KS	KS	KS	KS	KS	KS	KS	KS	G	G	KS	I	G	I	I	I	I	I	G
		9	Financial Resources	Knowledge Source / Govt / Shareholders	KS	KS	KS	KS	KS	KS	KS	KS	KS	G	G	KS	S	G	S	S	S	S	S	G
		10	Background IP	Knowledge Creator / KTI	KC	KC	KC	KC	KC	KC	KC	KC	KC	KTI	KTI	KC	KC	KC	KC	KC	KC	KC	KC	KC
		11	Foreground IP	Knowledge Creator / KTI	KC	KC	KC	KC	KC	KC	KC	KC	KC	KTI	KTI	KC	KC	KC	KC	KC	KC	KC	KC	KC
	III. K. Performance	12	Ownership of Revenue Income	Knowledge Creator / Shared / KTI	KC	KC	KC	KC	KC	KC	KC	KC	KC	KTI	S	KC	S	KC	S	S	S	S	S	KC
		13	Ownership of Metrics	Knowledge Creator / KTI	KC	KC	KTI	KC	KC	KC	KC	KC	KTI	KTI	KTI	KC	KTI	KTI	KTI	KTI	KTI	KTI	KTI	KTI
		14	Unit of Performance & Reporting	Knowledge Creator / KTI / Other	KC	KC	KTI	KC	KC	KC	KC	KC	O	KTI	KTI	KC	KTI	O	KTI	KTI	KTI	KTI	KTI	O

Table 5
– Agency dimension – results of categorization and coding.

KTI dimensions		#	Category	Categorization	KTI1	KTI2	KTI3	KTI4	KTI5	KTI6	KTI7	KTI8	KTI9	KTI10	KTI11	KTI12	KTI13	KTI14	KTI15	KTI16	KTI17	KTI18	KTI19	KTI20
AGENCY	IV. KT Activities: what do KTIs do?	15	Foresight and diagnostics	Undertaken / Not Undertaken	NU	NU	U	NU	NU	NU	NU	NU	U	U	U	NU	NU	NU	NU	NU	NU	NU	NU	NU
		16	Scanning and information processing	Undertaken / Partial / Not Undertaken	NU	NU	P	NU	NU	P	NU	NU	P	U	U	NU	U	U	P	P	U	P	P	U
		17	Knowledge processing, generation and combination	Creation/ Dissemination / Diffusion / Adoption / Capitalisation	CDDAC	CDDAC	CDD	CDDAC	CDDAC	CDDAC	CDDAC	CDDAC	DDA	CDDAC	CDDAC	DD	DDA	DD	DD	DDA	DDA	CDDAC	CDDA	DD
		18	Gatekeeping and brokering: Network building	Undertaken / Partial / Not Undertaken	U	U	U	U	U	U	U	U	U	U	U	U	U	U	P	U	U	P	U	P
		19	Gatekeeping and brokering: Contracts	Issuer / User	I	I	U	I	I	I	I	I	U	I	I	U	U	U	U	U	U	I	I	U
		20	Crowdsourcing	Instigator / Referrer / Not Undertaken	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	I	I	R
		21	Testing, validation and training	Undertaken / Partial / Not Undertaken	P	P	NU	P	P	P	P	P	P	U	U	NU	NU	NU	P	NU	NU	P	P	NU
		22	Accreditation and standards	Issuer / Contributor / Not Undertaken	C	C	NU	C	C	C	C	C	C	I	I	NU	NU	NU	NU	NU	NU	C	NU	NU
	V. How are the activities regulated?	23	Process of governance: Regulation and arbitration (Dispute resolution)	Leader / Referrer / Not Undertaken	L	L	R	L	L	L	L	L	L	L	L	R	NU	NU	R	NU	NU	R	R	NU
		24	IP management	Undertaken / Partial / Not Undertaken	U	U	NU	U	U	U	U	U	U	U	U	NU	NU	NU	NU	NU	NU	U	P	NU
		25	Commercialisation: exploiting the outcomes	Undertaken / Partial / Not Undertaken	P	P	NU	P	P	P	P	P	P	U	U	NU	NU	P	NU	NU	NU	P	P	P
		26	Assessment and evaluation	Undertaken / Partial / Not Undertaken	P	P	NU	P	P	P	P	P	P	U	U	NU	NU	NU	NU	NU	NU	P	NU	NU

Table 6
– Simplified KTIs Structure and Agency Typology

Dimension		Traditional KTIs(KTIs 1, 2, 4-8) [partly KTI3]	Regional-cluster KTIs(KTI 10; 11)	Virtual-community KTIs (KTI 9; 12)	Digital KTIs(KTIs 13-20) [partly KTI3]
Structure	Knowledge strategy	• Physical premises in-house/arm-length • Exclusively serving its home institution, its region(s) and sectoral focuses • Governed by the home institution	• Physical location but remote from the various HEI hosts. • Exclusively serving the regional HEIs • Governed by an agreed protocol between the regional HEIs	• Operating solely virtually and not having a permanent "digital home" (platform) • Being an in-house service for a single HEI (semi)prescribed governance by a host HEI	• Entirely virtual activities • Non-exclusive, serving U2B KT globally across various sectors • Independent of universities or businesses, self-governed
	Knowledge asset ownership	• Income from HEI allocation of funds • Knowledge created vested in home HEI unless stipulated by 3rd party funding agreement.	• Income from regional HEIs • Knowledge created owned by home HEI unless stipulated by 3rd party funding agreement.	• Income from HEI allocation of funds • Knowledge created vested in home HEI unless stipulated by 3rd party funding agreement.	• Market-income driven relying on shareholders' funds • All IP belongs to knowledge creator unless agreed otherwise (transferred w. agreement)
	Knowledge performance	• All revenues returned to HEI (in-house directly and arm's length via Charitable contribution) • Performance evaluation by HEI	• Shared revenues returned to host HEIs on a contract-by-contract basis. • Aggregate performance by regional HEIs	• All revenues returned to HEI (in-house directly and arm's length via Charitable contribution) • Performance evaluation by HEI	• Owning the revenue of matchmaking • Self-evaluating
Agency	KTI activities	• Full range of activities undertaken including foresight, scanning, creation, recombination to diffusion. • Gatekeeping and Brokering • Limited but emergent crowdsourcing. • Testing, validation and standardisation (on occasion) • Limited engagement with standardisation.	• Limited activities focussed on recombination and diffusion. • Gatekeeping and Brokering. • Limited but emergent crowdsourcing. • Testing & validation. • Collective engagement on standardisation.	• Limited activities: broader activities spectrum with public ownership and more limited activities set with private ownership.	• Matchmaking; partially: information scanning & processing. • No knowledge generation, but combination; some crowdsourcing • Exceptional testing and validation • No standards setting
	How are the activities regulated?	• Full IP Management • In-house dispute resolution • Full commercialisation and exploitation.	• Full IP Management • In-house dispute resolution (w. r.t. home institution(s)) • Full commercialisation and exploitation	• Limited evaluation activities: broader activities spectrum with public ownership and more limited activities set with private ownership.	• Partial IP management; limited • No dispute resolution • No outcomes exploitation or technology evaluation, but reports.

data and compared not only the pre-coded structure/agency characteristics of the clustered KTIs but also any further qualitative peculiarities that may explain these clusters. Table 7 (supported by Appendix 3 and 4), explains the characteristics which form the dimensions in Figure 1 and thus, help us understand the KTIs clusters we received: cluster 1 (KTI 1, 2, 4-8), cluster 2 (KTIs 13-20) and cluster 3 (KTI 11 & 12).

Cluster 1 is distinguished from two other clusters by the first dimension. Dimension one is informed by twelve characteristics predominantly related to the KTIs' governance and autonomy from the institutions they serve. That dimension is somewhat replicating the initial, literature-based structure vs. agency divide – let's take a closer look at these twelve characteristics to illustrate that divide.

Concerning the strategy of the knowledge transfer organizations, dimension one distinguishes cluster 1 in twelve following ways. (1) Virtual or mixed forms of the KTIs activity location explain the distance between cluster 1 (predominantly physical KTIs) and cluster 2 (predominantly virtual ones). (2) Activities' perimeter distances clusters 2, 3 further away from cluster 1 of KTIs serving a single/'parent' institution. (3) Proximity distances clusters 2 and 3 of KTIs independent from the knowledge source from cluster 1, where KTIs belong physically and administratively to their 'parent' institution. (4) Autonomous locus of governance distances clusters 2 and 3 from the first cluster of intermediaries which are governed by their hosting university. (5) Source of the KTIs salary with revenue income being a source for paying staff for solely cluster 2, where one of the common business models is to charge large corporations for customized technology/partner search: "*Well what happens is the big corporates pay us to find innovations for them. So, the*

corporates pay us to find innovations, and the platform is the sort of, the centre, the hub of how that works. So why we can offer this for free for universities is the corporates pay us to find things." (KTI 17).

Continuing on characteristics of dimension one, (6) Independent facilities supported by profit-making distinguish cluster 2 from others. (7) Financial resources coming from shareholders distance cluster 2 of private KTIs from others. (8) Ownership of performance metrics and related (9) unit of reporting distinguish KTIs in clusters 2 and 3 owning the metrics from the cluster 1, see KTI 13 counting the number of clients and partners acquired in a period of time: "*We got a very small amount of funding… and we only worked with about 40 companies then or individuals from 40 companies, but we managed to match in two months 25 per cent of all of the technology we got from the universities with a collaborative partner. So,… we got private investment and… (Two) years on we are working with, 51 institutions now. That's 37 in the UK which include Cambridge, KCL, Bristol, Leeds, so essentially in the UK I don't know if you've heard of it before but we have what is called the Russell Group."* (10) Scanning and information processing are performed in clusters 2 and 3 compared to cluster 1. (11) Regulation and arbitration are not undertaken in clusters 2 and 3, in contrast to cluster 1. (12) IP management if undertaken in clusters 2 and 3 – then only partially, while this activity is undertaken in the cluster 1.

All of the above mentioned twelve characteristics to a certain extent related to the structural configurations of the KTIs and to the role of the KTIs in leading the management of the knowledge transfer, which eventually appear either structure- or agency-driven. Villani et al., (2017) and later Perkmann et al., (2019) highlight how university-industry collaboration intermediaries commit to bridging the diverse institutional logics of academia and firms. Goel et al., (2017) further highlight the specific areas where universities and firms differ in their institutional logics: time horizon, type of research projects, ownership and disclosure of research results, research funding, and the role of peers. The first dimension resulting from our cluster analysis suggests that institutional logics differences exist not only in the context of university-industry collaboration itself, but also within the spectrum of hybrid organizations intermediating university-industry knowledge transfer.

The second dimension of the matrix in Figure 1 is shaped by four characteristics which distinguish cluster 3 (KTIs 10 and 11 – we tend to label them "regional-cluster" KTIs in our initial, manual data analysis, Table 6) from the other KTIs (Table 7): (1) background IP owned by the KTI itself and not the knowledge creator; (2) foreground IP owned by the KTI itself and not the knowledge creator; (3) testing, validation and training function performed by the KTIs 10 and 11 in contrast to other KTIs in our sample not performing it or performing it only partially; (4) commercialisation, exploiting the outcomes performed by the KTIs 10 and 11 in contrast to other KTIs in our sample not performing it or performing it only partially.

These four characteristics distinguish KTIs 10 and 11 as somewhat even more independent from any 'host' institutions or knowledge market circumstances than other KTIs. Baglieri et al., (2018) (followed by Cunningham et al., 2020; Miller et al., 2021) are among the first authors noting the difference in the rationale, value creation and value capture among knowledge transfer intermediaries. Those, however, focus yet on solely traditional technology transfer offices, although acknowledge other emerging forms of intermediaries. The second dimension arising from our cluster analysis shows further distinction among the existing KTIs, with KTIs 10 and 11 appearing more self-sustainable, or less bounded in their organizational rationality (March, 1988) by a host institution or by the knowledge market – and more entrepreneurial when it comes to the essence of the knowledge transfer – knowledge and technology development and exploitation. Furthermore, those reflect the high degree of the KTIs' involvement in cognitive processes behind knowledge creation and transfer. Following Fuenfschilling and Binz, (2018) in their drawing on cognitive regime theory and the distinction between local and global cognitive regimes arising similarly to our study from institutional complexities, we tend to see the less bounded rationality of the KTIs 10 and 11 as a cognitive regime partly shaped by their institutional characteristics. We proceed with interpreting both of the resulting dimensions, links between them as well as clusters along with discussing those against the existing literature in the following section.

5. Discussion

Reflecting on our spectrum of university-industry KTIs, the structure vs. agency lens has enabled the contrast of the features of traditional KTIs against virtual and digital entities. From our sample, the traditional university-industry KTIs remain either in-house or arms-length, typically exclusively serving their home institution and replicating its rigid structures and governance, as noted in the literature (Schoen et al., 2014). However, we identify more contemporary forms of university-industry KTIs where structural boundaries blur due to digitalization (Perkmann and Walsh, 2009; Sjöö and Hellström, 2019), thus extending the literature. We found they present as more autonomous, non-exclusive and enjoy ownership of their performance metrics and thus control which value-adding services they offer. This suggests that they have an end-user focused strategic flexibility that responds to market needs (Johnson et al., 2003). Such strategic flexibility is evident in high technology arenas and is necessary for managing what Evans (1991) terms "capricious settings." The structurally bounded vs. autonomous differentiation in our sample reinforces the prevalence of the structure vs. agency divide, when intermediating university-industry collaborations. However, our findings suggest by looking beyond structure vs. agency to identify a second dimension that distinguishes between the different forms of the university-industry KTIs. This is illustrated by university-industry KTIs involved in technology testing, validation and technology commercialisation, coupled with vested ownership of background and foreground IP. We suggest this implies a level of entrepreneurial activity, enabled by choices and rationale beyond simply facilitating the knowledge or technology exchange.

Previous research on traditional organisations (March, 1988), and particularly on KTIs (Alexander and Martin, 2013) has identified that individuals lack strategic knowledge and suffer asymmetries of information when operating at a sub-organisational level. At the same time, following the theories of instrumental rationality (relational choice – (Thorson et al., 1975) organisational decision-making will not only operate, governed by structural or agent regimes, but also depends on an individual's sense-making according to decentralised (non-structurally governed) choice, by applying the agents own predetermined cognitive rationales. Informing our second research question 'how KTIs act' accords with the second dimension (arising from our cluster analysis) which is facilitating the university-industry relationships versus undertaking more entrepreneurial activities in the knowledge management space. This provides an opportunity to rationalise the behaviour noted as bounded rationalities in KTIs organizational decision-making. In progressing from observing the action and trying to make sense of action (appearing bounded and unbounded) we have attempted to rationalize this against theories of *cognitive regime*, but we appreciate however that this represents a logic step, which could be interpreted in other ways. However, considering Fuenfschilling and Binz (2018) concepts of cognitive rationality, our analysis could imply that although the existing KTIs may all understand and to a certain extent follow a common global cognitive regime (a unified understanding of socio-technical system), they still behave governed in part by their individual cognitive regime, in being more or less bounded cognitively by either knowledge creators (universities in this case), knowledge receivers (firms) or knowledge markets (interactions and transactions between the two) (Cahoy, 2021).

Arising from the interplay between structure vs. agency and informed by our discussion on the rational choice we introduce Figure 2, which describes four potential combinations of institutional logics and cognitive regimes that are evident in our study and substantiated by the multiple correspondence analysis. We suggest these begin to reflect

Table 7
Categorical variables

	KTI Characteristics	Full codes	Dim.1	Dim.2
X1	Location of activity	Physical vs. Virtual	0.543	0.222
X2	Perimeter: focus of value-added activities	Exclusive vs. Non-Exclusive	0.837	0.049
X3	Perimeter: definition of operational location	Local / Regional / National / Cloud	0.702	0.303
X4	Discipline: sector focus	Sector Focus vs. No Focus	0.079	0.284
X5	Proximity to knowledge source	In-House/Arms-Length /Independent	0.837	0.049
X6	Locus of governance	Prescribed / Semi / Autonomous	0.634	0.081
X7	Staff – who pays their salary	Knowledge Source/ Govt / Revenue Income	0.856	0.567
X8	Facilities	Knowledge Source /Govt / Independent	0.856	0.567
X9	Financial Resources	Knowledge Source / Govt / Shareholders	0.856	0.567
X10	Background IP	Knowledge Creator / KTI	0.032	0.913
X11	Foreground IP	Knowledge Creator / KTI	0.032	0.913
X12	Ownership of Revenue Income	Knowledge Creator / Shared / KTI	0.602	0.479
X13	Ownership of Metrics	Knowledge Creator / KTI	0.805	0.022
X14	Unit of Performance & Reporting	Knowledge Creator / KTI / Other	0.831	0.025
X15	Foresight and diagnostics	Undertaken / Not Undertaken	0.008	0.385
X16	Scanning and information processing	Undertaken / Partial / Not Undertaken	0.686	0.27
X17	Knowledge processing, generation and combination	Creation/ Dissemination / Diffusion / Adoption / Capitalisation	0.5	0.238
X18	Gatekeeping and brokering: Network building	Undertaken / Partial / Not Undertaken	0.131	0.021
X19	Gatekeeping and brokering: Contracts	Issuer / User	0.354	0.17
X20	Crowdsourcing	Instigator / Referrer / Not Undertaken	0.07	0.03
X21	Testing, validation and training	Undertaken / Partial / Not Undertaken	0.412	0.923
X22	Accreditation and standards	Issuer / Contributor / Not Undertaken	0.731	0.948
X23	Process of governance: Regulation and arbitration (Dispute resolution)	Leader / Referrer / Not Undertaken	0.677	0.26
X24	IP management	Undertaken / Partial / Not Undertaken	0.554	0.22
X25	Commercialisation: exploiting the outcomes	Undertaken / Partial / Not Undertaken	0.366	0.971
X26	Assessment and evaluation	Undertaken / Partial / Not Undertaken	0.731	0.948

organisational types in our sample.

The first, *rigid*, implies a rigidly structured and cognitively bounded organisation, with in-house or arms-length location, governed and managed by the host institution and unable to disengage. Strategy, decisions on which services to offer, how these will be monitoring are all centrally prescribed and thus instil a cognitively bounded environment within which to make decisions [From our study these were KTIs 1,2,4,5,6,7 & 8]. From a risk perspective, however, this is the most secure – with the KTI benefitting from senior lending to secure service funding shortfalls and with insurances and liabilities rolled into the host's trading activity (Table 4). These are traditional, physical knowledge transfer intermediaries.

In contrast, our *agile* type, implies both structurally-free and cognitively unbounded entities able to reflect changes in the market, configure their offerings swiftly and engage with diverse stakeholders effectively, while involving themselves in technology-led or knowledge-based entrepreneurship [These were KTIs 10, 11]. Both of these KTIs are German institutions agent in their focus and their partner selection. Their funding model is an amalgam of government and revenue income and these KTIs are considered as mature and public, having physical premises instead of operating digitally. This is contra to base assumptions, which might suggest agility is a function of adopting only digital platforms (Cahoy, 2021; Lee, 2021); the bastion of contemporary, independent and market-driven organisations.

Our third type, *agent-bounded*, implies a KTI organization, which is although mostly agency-driven, cognitively is still rather bounded – whether it is a public or private entity – which restrains a KTI from performing a wider spectrum of knowledge transfer related activities [we found these in digital KTIs 13-20]. The fourth type, *rigid-unbounded* implies an organization that is structurally still embedded or strongly linked, but cognitively unbounded – able to establish and follow its own rationale. None of the studied KTIs qualified for this category. This could simply imply a limitation of our sample, but alternatively, this category may represent a possibly limited-working arrangement in the current context of KTIs and their evolution – similarly to the 'dog' type of organizations in Boston Consulting Group Growth-Share Matrix. To become *rigid-unbounded* traditional approaches to KTI could be adopted in the governance and operational structures prescribed by the rigid models, but with a focus on creating unbounded cognitive protocols within the staff. Furthermore, some of the studied KTIs (the virtual community KTI 9 and 12, as well as an example of a traditional one, KTI 3) seem to be outliers and only loosely belong to any quadrant in our matrix in Figure 2.

Our model subsequently poses additional questions for future studies – for example is there a strategic direction and therefore aspirations for institutions to change? Would a rigid KTI that aspires to become an agile KTI know what steps could they take? According to Alexander and Manolchev (2020) in their analysis of the Future of Universities thought-book (Davey et al., 2018), current economic and market drivers are dictating HEIs to become more flexible and more market-led. If this is the case then this direction of travel might be pertinent, but which step might be the most effective in the short term, a move to agent-bounded or toward rigid un-bounded model (that eludes our analysis currently)? Furthermore, are our outliers on the move between the different distinguished KTIs types or, are those rather signalling additional dimensional characteristics we have not identified? – only a larger sample will be able to address this question holistically. We suggest that this debate around structure vs. agility be extended to incorporate other, new online and platform-based KTIs that may be developing their offering in the marketplace – to see if they are indeed continuing in the independent spirit of our findings or whether the university incumbents are entering the marketplace and proving new virtual, but perhaps still structurally orientated offerings. There is also a need for future research to explore the skills, capabilities and competencies required by technology transfer professionals that are aligned to the emerging growth in virtual networks and digital forms of intermediation in university-to-industry collaborations.

6. Conclusions

Given the potential for rapid evolution of KTIs in the university-industry context, enabled by digitalised platforms, online collaboration and wider acceptance of virtual forms of existence, the purpose of this study was to develop an approach, that enabled the comparison of different forms of university-industry knowledge transfer intermediaries. Our novel analytical framework (presented in Tables 1a and 1b and validated in our Findings section) highlighted key differences between their structure and their approach to offering services (their agency), which led us to the following conclusions.

Prior studies (Cahoy, 2021; Colyvas and Powell, 2006; Schoen et al., 2014), exploring the dynamics of university-industry KTIs, observe an expanded value chain. Our analysis confirms the spectrum of

university-industry knowledge transfer intermediation, in terms of their structure and their functions (agency), has expanded (as summarised in Tables 4 and 5), aligning with conclusions made by Hayter et al. (2020). Similarly, as B2B digital platforms (Dushnitsky and Klueter, 2017) add value from match-making, networking and scaling-up, we note our contemporary, virtual and digital KTIs stretch towards providing these functions, perhaps as a natural response to overturning the remaining connectivity barrier in university-industry relationships (Galán-Muros and Plewa, 2016). We suggest this expansion of the value chain has also triggered more nuanced parent-subsidiary relationships in some of our traditional KTIs– varying in terms of their respective institutional logics.

In more detailed terms, we also conclude that: (1) our most 'Rigid' KTIs were not always the oldest, but were tied closely in terms of funding, geographic location, IP-retained ownership and provision of services (to their host institution). They also tend to offer the largest range of services, whilst controlling the transfer of knowledge with a range of contractual and IP related processes and conditions. (2) Our most 'Agile' (whilst not always youngest) have either found ways to create operational conditions enabling a culture of open and unbounded decision making, and who control and configure their services accordingly. (3) The digital KTI platforms, whilst controlling their destiny and configuring their services also developed a tendency to stifle their own agency, by adopting bounded decisions around activity regulation. (4) Our virtual, community-based KTIs seem to either represent a transition between different modes or represent an additional dimension – to be further explored.

By applying more detailed theoretical perspectives of structure vs. agency and subsequently by considering bounded vs. unbounded rationality, we identified a host of respective differences between traditional and emergent, virtual and digitally-enabled KTIs. Specifically, we identified key differentiators of 'knowledge asset ownership', 'strategy and performance' and also the 'spectrum of intermediation' functions undertaken. We also identified more nuanced differentiation, where agile organisations (agent-led and cognitively unbounded) were not, as we might have predicted, the new, digitally-enabled, revenue-funded and marketized ones. We also identified that new, digital and platform-based university-industry KTIs were set up to be more agent and not structurally-tied but behaved (and offered services) indicating they were bounded in their decision making and rationality – thus adopting digital connectivity alone did not lead to full-scale agility.

Considering the conclusions, arising from our theory-building study, we posit the following research propositions to be further tested with additional cases:

- Proposition 1: *structure and agency characteristics, proposed in our analytical framework, strongly distinguish structurally-restricted (rigid) knowledge transfer intermediaries from agency-driven (agile) intermediaries – particularly in the context of university-industry collaboration.*
- Proposition 2: *the cognitive regimes of knowledge transfer intermediaries, in terms of being bounded or unbounded, can be either an unconscious structural dictat (from its host HEI) or conversely driven by direct access to knowledge and technology marketisation.*
- Proposition 3: *the digital nature of a knowledge transfer intermediary may allow it to follow its own institutional logic and thus be agency-driven, but it does not automatically determine an unbounded cognitive regime. An unbounded cognitive regime is biased by KTIs providing technology testing, validation and training combined with vested ownership in the background and foreground IP, where freedom to further commercialize and exploiting exists.*

Our paper is not without limitations. The exploratory nature of the study lends itself to issues of asymmetry of information, due to the rather different domains that the respective KTIs reside. Likewise, there was

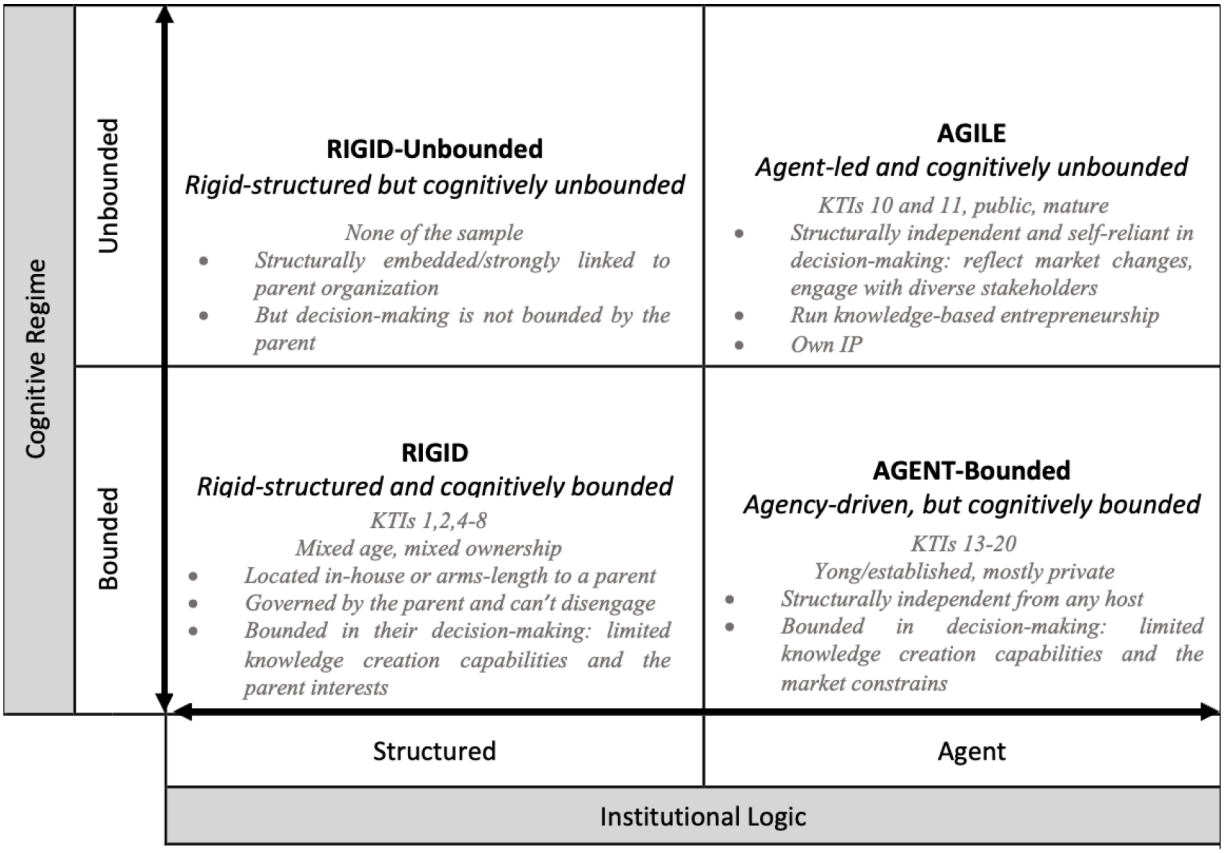

Figure 2. –Configurations of Institutional Logic vs. Cognitive Regime

also a considerable challenge of retaining consistent contacts throughout the key steps of the data collection. A larger data cohort could be used to validate our final typology of KTIs, using the analytical framework provided, both within and beyond the knowledge and technology transfer context. The collection of data could then take a more rigorous and systematic approach to assess the success characteristics and therefore create some interesting comparisons between what is seen as success from rigid versus agile and what is seen as success from cognitively bounded versus unbounded organisations. The cognitive regime dimension per se needs to be analysed in more detail via, for example, operationalizing and measuring how bounded the decision-making is for what types of KTIs and what other factors (beyond structure and agency) actually bound the KTIs rationale and decision-making. Finally, there were also considerable challenges associated with collecting data across different geographical domains, which in turn limited our sample size.

Noting the above limitations, our academic contribution is threefold. Firstly, we are addressing Good et al. (2019)' and Hayter et al. (2020) who call for a more holistic approach towards the university-industry knowledge transfer ecosystem. We address these calls by extending the spectrum of university-industry KTIs from traditional through virtual, community-enabled to digitally-enabled platforms. Based on our data analysis we developed a typology of university-industry KTIs that reflects the spectrum of university-industry KTIs. Our typology can be used by future scholars to categorise KTIs and enable senior managers and strategists, concerned with shifting to more demand-led provisions, whilst understanding the interrelationship with technology-developed platforms (building upon the studies by Landry et al., 2013; Schoen et al., 2014).

Secondly, our findings show that whilst university-industry KTIs appear either, predominantly structure or agency-driven and institutional logics differ not only among firms but also among intermediaries (Perkmann et al., 2019; Villani et al., 2017), there is at least one other distinguishing dimension affecting their actions – the boundaries in the rationality of the decision-making. Following Fuenfschilling and Binz (2018) in their drawing on cognitive regime theory and the distinction between local and global cognitive regimes arising similarly to our study from institutional complexities we thus distinguish between cognitively bounded and unbounded knowledge transfer intermediaries in university-industry collaboration, where boundaries are dictated either by a host institution or by technology/knowledge market. For entrepreneurs starting up or running virtual intermediaries, we also illuminate some pitfalls of adopting bounded decision making and dispute resolution in service offerings accordingly.

Thirdly, we further contribute to the ongoing interdisciplinary efforts in management science (Sick and Bröring, 2021; van Baalen and Karsten, 2012) . We develop its branch on knowledge transfer intermediation, via utilizing the conceptualizations from social sciences (the structure and agency debate) and behavioural economics (bounded rationality theory) (Koumakhov and Daoud, 2020; Whittincton, 1988) and via exploring how those intertwine and complement each other in the context of knowledge transfer intermediation. We particularly show, that while a structure-agency divide explains the diversity in KTIs' institutional logics, structural complexities also seem to shape KTIs' cognitive regimes.

Considering a practical contribution, the structure and agency dimensions (see Tables 4 and 5) can be used by knowledge transfer professionals to assess their current KTI. The analytical framework developed and validated in this study allows knowledge professionals and their relevant stakeholders, to consider how and what to change, should they wish to shift their strategic and operational models perhaps to become more agile and market-facing. Likewise, they can also consider the blend of cognitive freedom and digitally-enabled connectivity they may choose to adopt to enable greater market reach or international access for their knowledge. Our typology (Figure 2) also provides a visualisation with which to debate their future evolution, particularly the medium to the long-term strategic direction of their university-industry KTI model.

Thus the practical implications of our study are that technology transfer and knowledge professionals need firstly be aware of the changing university-industry KTI models, and secondly based on this awareness, determine changes (if any) that are warranted to their current model. The evolution of digital and virtual-community KTIs have the potential to disrupt significantly the traditional university-industry KTI model, although it has not been fully revealed yet (Cahoy, 2021). This in turn has the potential to change the agency dimension of university-industry KTI activities and whether evolving models of KTI have a further niche and or differentiated activities. Moreover, newer university-industry KTI models can call into question the value and differentiating purpose of physical locations.

From a policy perspective, our study highlights a key question for policymakers: which models of university-industry KTI provide public support at a national level, particularly in publicly funded universities and research centres? Depending on how well developed and established university-industry collaborations are, policymakers should consider policy experiments that support digital and virtual-network university-industry KTIs, which compliments their existing activities but could lead to greater flexibility and also achieve a wider international reach. The later could appear particularly relevant for peripheral regions (Cunningham et al., 2020). Accommodating some of the structural and agency dimensions, evident in the more contemporary university-industry KTI models might also future-proof the traditional university-industry KTI models toward long-term survival (Cahoy, 2021).

Finally, our study opens up new avenues for further research that researchers can build upon. There is a need to understand the micro-level processes and practices that shape and underpin the structure and agency dimensions that we have identified. Taking a processual approach at the micro-level not alone advances our understanding but can be of practical professional benefit to technology transfer and knowledge professions (Bidart et al., 2013; Cunningham and Menter, 2020; Dawson, 2019; Pye and Pettigrew, 2005). There is a need to understand how non-market factors strategy (government, regulations corporate political activity, corporate social responsibility) (Bach and Allen, 2010; Mellahi and Frynas, 2016) shape the structural and agency dimensions of KTI models. With the advent of big data and further digitalisation of many industries and sectors, there is a need for further research that sheds further light on how does this shape university-industry collaboration KTI knowledge strategy and knowledge performance (Liedong et al., 2020). Furthermore, given the relative newness of digital and virtual-community university-industry KTIs there is a need for further empirical studies focusing on their knowledge performance, metrics, human capital configurations and the business models that underpin their activities.

CRediT authorship contribution statement

Ekaterina Albats: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition. **Allen T. Alexander:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization. **James A. Cunningham:** Conceptualization, Validation, Resources, Writing – original draft, Writing – review & editing.

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Appendix 1. Intermediating university to business knowledge transfer – the structure and agency dimensions

The structure dimension relates to how the knowledge transfer intermediaries are structured and organized, where we highlight three sub-streams of literature – knowledge strategy, knowledge asset ownership and knowledge performance.

Knowledge Strategy: *location of knowledge exchange activity* implies recognising the importance of face-to-face interaction (Gertler, 2003), the importance of tacit knowledge transfer (Murray and Peyrefitte, 2007) and high versus low 'media richness' in transfer channels (Alexander and Childe, 2013), comparing '*physical*' (face-to-face) vs '*virtual/digital*' activity when knowledge origin/location shows less/no influence compared to diverse technological and institutional knowledge origin (Natalicchio et al., 2018). *Degree of exclusivity* refers to Schoen et al.'s (2014) typology of university-industry collaboration intermediaries, to establish if services are for a single university or many, which in turn is expected to affect the intermediary' maturity level (Secundo et al., 2017). *Perimeter of operational location* recognises differentiation between '*local*' focus areas, '*regional*', '*national*' (Kreiling and Scanlan, 2020; Muscio, 2010; Schoen et al., 2014) or countries on a '*virtual or cloud-based platform*' (Dushnitsky and Klueter, 2017). Building on this, specialisation toward only particular, '*sector-focused*' knowledge or '*universal*' relates to the *degree of discipline specialisation* (Schoen et al., 2014; Secundo et al., 2017). KTIs may also vary by *operational proximity* to a university acting as a knowledge source (Alexander and Miller, 2017; Gertler, 2003; Petruzzelli and Murgia, 2021; Petruzzelli, 2011; Villani et al., 2017). This is to distinguish between '*in-house*' (or internal to the university, (Wright et al., 2008b), '*arms-length*' (often a subsidiary company located on-site or nearby, (Upstill and Spurling, 2008) and '*external*' (Wright et al., 2008b). Further dimension in terms of their structure depends on their *locus of governance* – whether KTI strategy is '*prescribed*' by the focal institution(s), only partly '*semi-prescribed*' or it is a fully '*autonomous*' corresponding with Schoen et al.'s (Schoen et al., 2014) studies and *level of trading autonomy* from Markman *et al.*(Markman et al., 2005)' university quasi archetypes ('*traditional*', '*non-profit*', *and* '*for-profit*').

Knowledge Asset Ownership: Arising from a resource-based viewpoint, aligned with property rights theory, Acedo et al. (2006) position *single ownership* vs. *shared ownership* (Schoen et al., 2014) – articulated as four sub-elements: KTI' *staff* [labour ownership - encompassing the linked dichotomy of "*being paid a salary*" vs. "*making deals*" (J. Cunningham et al., 2020; Jensen et al., 2003; Siegel et al., 2004)]. KTI' *facilities* as physical resources (Barlatier et al., 2017; Bozeman, 2000; Finne et al., 2009; Kochenkova and Grimaldi, 2015). KTI' *financial resources* – capital for the creation of the KTI (Bonaccorsi et al., 2021). *Intellectual property* (Liu, 2010) as a codified, protectable knowledge (Agrawal, 2001; Lebeskind, 1996), determining ownership by either the '*knowledge source*' (the focal institution), by '*government*' or in case of a fully-independent KTI, funded entirely from the '*revenue income*' and where any capital is composed by the shareholders' funds. The codified knowledge, could take the form of '*background*' or '*foreground IP*' (Haan et al., 2020; Lie, 2020) and ownership by either '*primary knowledge creator*' (university) or by a '*KTI*', where IP is vested in the intermediary itself (Eggington et al., 2013).

Knowledge Performance: Exploring the activity of knowledge transfer: who owns the *revenue income* [e.g. license revenue (Friedman and Silberman, 2003)] creating options of '*university*', '*KTI*' or '*shared*' ownership (J. Cunningham et al., 2020); performance measurement of the transfer, in terms of *ownership of the metrics* and who defines the *units of performance and reporting* (Kreiling and Scanlan, 2020) with options of '*knowledge creator*' (university), '*KTI*' or '*third party*' corresponding to Schoen et al., 2014' and complemented by '*reporting obligations*'.

The agency dimension relates to functions performed by the KTIs (Sharifi and Liu, 2010), what type(s) of knowledge is offered (Schoen et al., 2014; Wright et al., 2008b) and relative level of freedom they have [within the respective rigidity of their structures – (Alexander et al., 2011)]. In contrast to structure, only a handful of studies contributed to the functional understanding, where some focus more on general innovation management (Agogu et al., 2013; Howells, 2006) or knowledge/technology transfer (Arnold et al., 2007; Dushnitsky and Lenox, 2005), and others take a particularly closer look at the university-industry interface (Alexander and Martin, 2013; Schoen et al., 2014; Wright et al., 2008b). Here we distinguish between what KTIs do and how their operations are regulated.

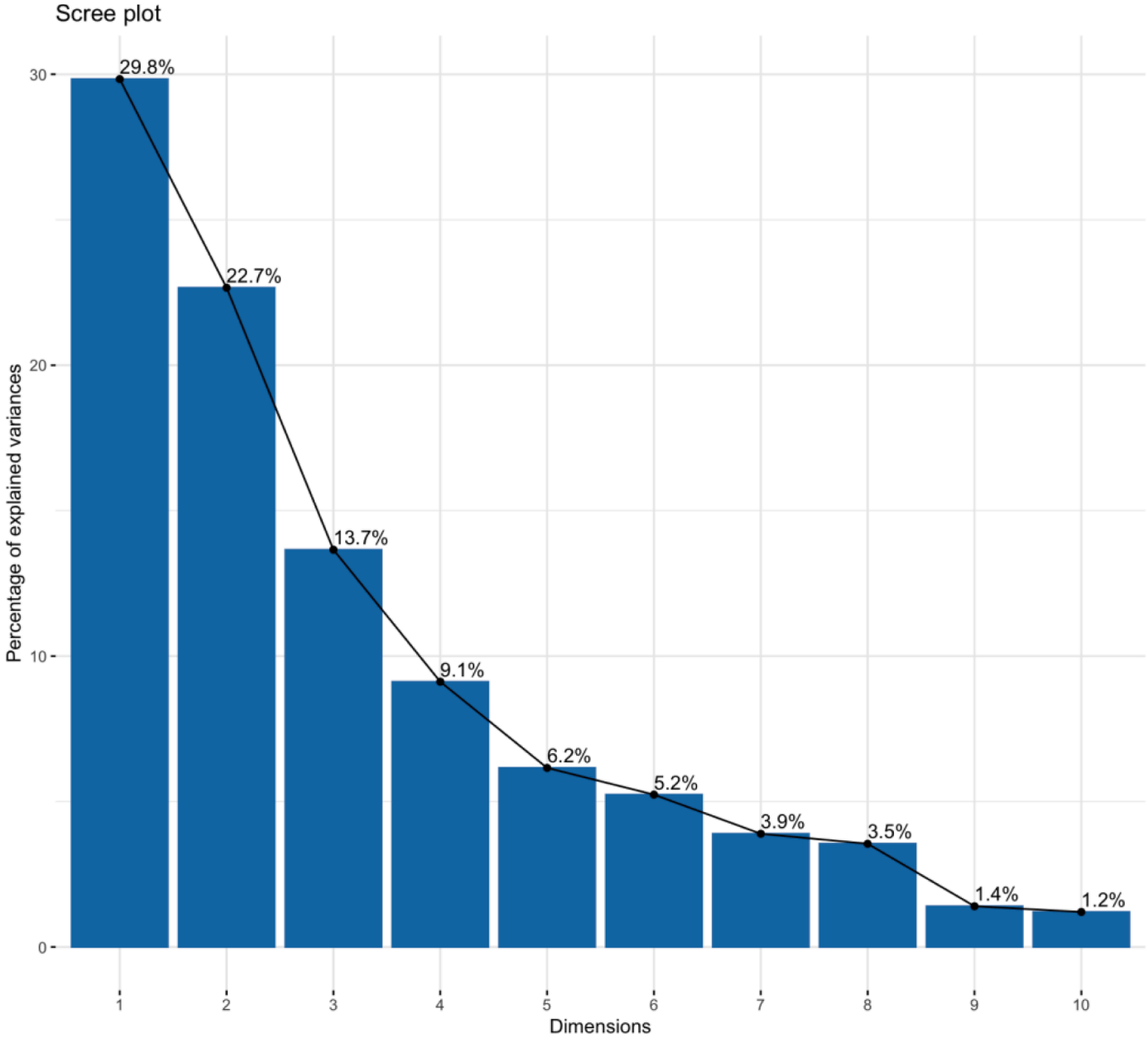
What KTIs do: Technology scanning, futurology and forecasting (Agogu et al., 2013; Arnold et al., 2007) presents *foresight and diagnostics,* with '*KTIs*' performing these activities, relying on the *knowledge creator* (host institution) or roadmaps from the '*knowledge receiver*' (Natalicchio et al., 2014; Rossi et al., 2021). Technology intelligence, scoping and filtering (Dushnitsky and Klueter, 2017) is performed as a function of *scanning and information processing* (Petruzzelli and Rotolo, 2015). '*KTIs*' collecting, analysing and collating information on potential partners, to assist the knowledge creator and/or receiver, or merely provide an '*infrastructure*' (e. g. search mechanisms or database) to support the actors performing this function themselves [and thus reduce opportunity or switching costs] or rely on '*external*' intermediaries [as Regional Development Agencies and Public Research Centres (Wright et al., 2008a)].

Knowledge processing and combination/recombination, where Barlatier (2017) suggests that tacit knowledge is never transferred (duplicated identically), but it is always recreated by the receiver (and thus the knowledge disseminator takes part in the knowledge creation), combining this with Gera's perspectives (2012) leads us to KTI functions along the spectrum of knowledge '*creation*', '*dissemination*', '*diffusion*', '*adoption*' and '*capitalisation*' functions. As part of a gatekeeping and brokering function (including matchmaking and brokering) (Cranefield and Yoong, 2007; Howells, 2006), *network building* is increasingly relevant KTIs, to aid in reducing the costs of partner search (Agogu et al., 2013; Dushnitsky and Klueter, 2017). Again, the KTI provides '*infrastructure*', performs '*brokering*' or leave this function to the '*collaborating*' parties.

Contractual advice is important in gatekeeping and brokering [highly explicit in the U2B collaboration context (Alexander and Martin, 2013; Schoen et al., 2014; Wright et al., 2008b)], where KTIs carrying out the '*contract negotiation*' and '*authorising*', or alternatively rely on the agreements '*imposed*' by the knowledge creator or receiver (Schoen et al., 2014). *Testing and validation* – including testing, diagnostics, analysis and inspection, prototyping and pilot facilities, scale-up, validation and training, as a downstream element of the foresight function and may be performed by the '*KTI*', '*partially fulfilled*' or left to the '*knowledge creator or receiver*' (Agogu et al., 2013; Bolzani et al., 2021; Rohrbeck and Arnold, 2007; Silva and Ramos, 2021). *Accreditation* – including advice provision on standards, setting standards and verification, is particularly relevant in joint projects (Arnold et al., 2007; Cahoy, 2021), where '*KTI*' provides or leaves this function to a '*third-party*' agent. One function, emerging from the recent literature is *crowdsourcing* [a solution to distant search (Afuah and Tucci, 2012)], for leveraging the 'wisdom of crowds' (Saxton et al., 2013) by harnessing the collective intelligence genome (Malone and Laubacher, 2010; Still and Soens, 2016) and achieving extra synergy in the problem-solving (Baglieri et al., 2018; Schenk et al., 2019). KTIs can be '*instigators*' in the process of crowdsourcing, or can merely '*refer*' to others as service providers.

How are these services regulated: *Regulation and arbitration* either *as* self-regulation, informal societal-regulation or third-party arbitration relate KTIs to levels of autonomy (Markman et al., 2005; Schoen et al., 2014; Sutopo et al., 2019). '*KTIs'* may be fully responsible for solving the disputes between knowledge collaboration parties, may '*assist/be referred to*' in such cases or leave it to be solved entirely by the '*other party's*' lawyers. IP rights advice and management *protecting the results* *is* relevant (Alexander and Martin, 2013; Schoen et al., 2014; Wright et al., 2008b) and considering the degree of KTI involvement, maybe '*undertaken fully*'; '*partially*'; or left as a responsibility of '*in-house specialists*' (Alexander and Miller, 2017; Cahoy, 2021). *Commercialisation* – market research and business planning, sales network and selling, finding potential capital funding and organising funding or offering venture capital might be considered to go beyond the scope of KTIs, leaving these to consultants, incubators and accelerators, however knowledge-based entrepreneurship (Alexander and Martin, 2013; Baglieri et al., 2018) calls for such capacities in the U2B collaboration, being '*offered*', offered only '*partially*' or '*indirectly*'. *Evaluation of outcomes* as technology assessment and evaluation forms our final category in how these services are offered (Lafuente and Berbegal-Mirabent, 2019).

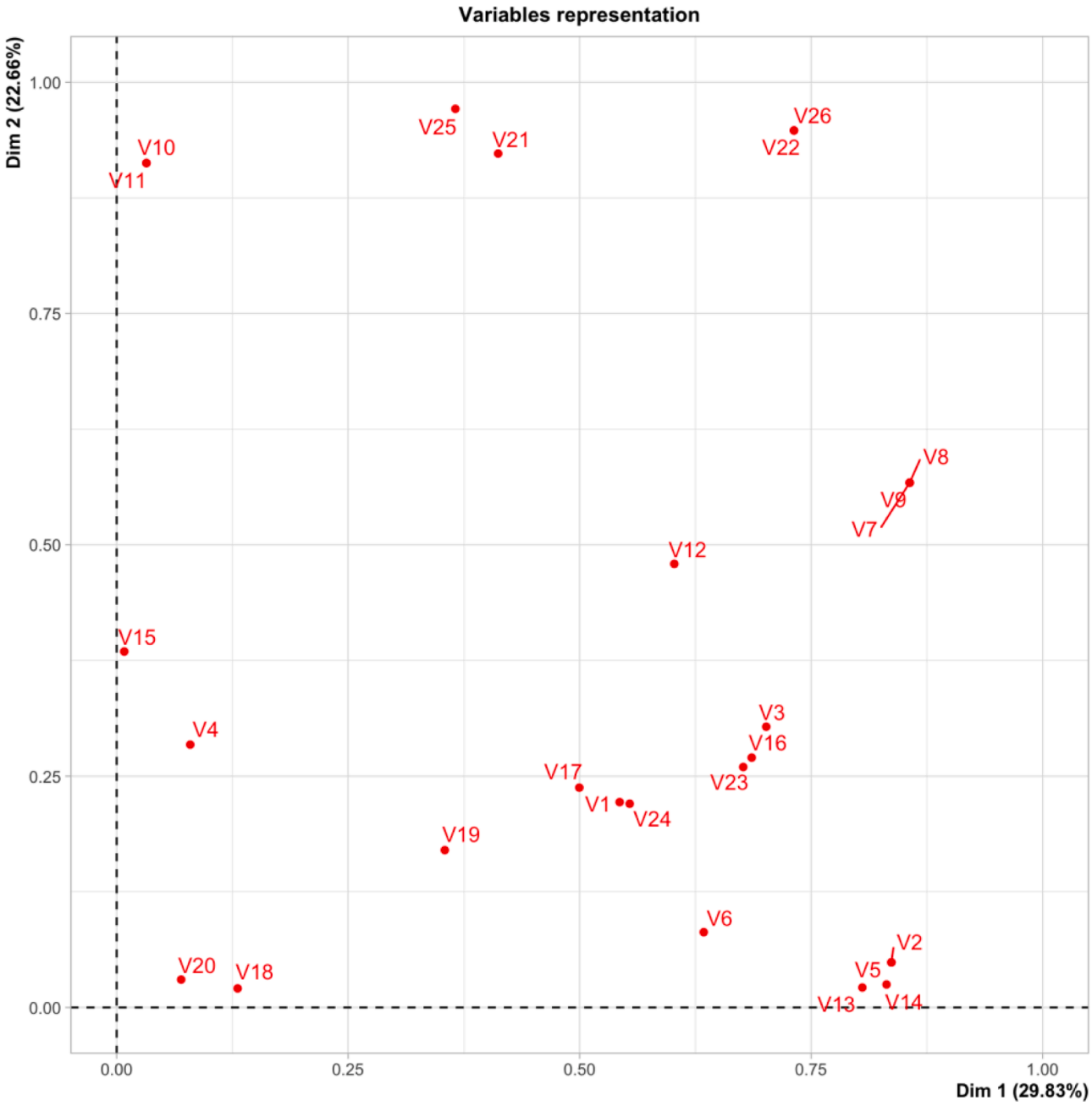
Appendix 2. Variances explained by the dimensions (Dim 1 & 2 cumulative: 52.5 %)



Appendix 3. Categories explaining the dimensions

Categories		Dim.1	ctr	cos2	v.test	Dim.2	ctr	cos2	v.test
Location of activity: Physical	X1_P	-0.737	1.977	0.543	-3.211	0.454	0.989	0.206	1.979
Location of activity: Physical+Virtual	X1_P+V	**0.845**	0.26	0.038	0.845	0.079	0.003	0	0.079
Location of activity: Virtual	X1_V	**0.725**	1.721	0.429	2.857	-0.513	1.137	0.216	-2.024
Perimeter: exclusive	E	-0.915	3.048	0.837	-3.987	-0.221	0.234	0.049	-0.962
Perimeter: non-exclusive	NE	**0.915**	3.048	0.837	3.987	0.221	0.234	0.049	0.962
Operational location: cloud	X3_C	**0.943**	2.27	0.479	3.018	-0.61	1.248	0.2	-1.95
Operational location: local	X3_L	-0.834	2.28	0.569	-3.288	**0.572**	1.41	0.267	2.254
Operational location: national	X3_N	**0.804**	0.471	0.072	1.168	0.07	0.005	0.001	0.101
Operational location: regional	X3_R	-0.353	0.091	0.014	-0.513	-0.508	0.247	0.029	-0.738
NoSectorFocus	NF	-0.163	0.145	0.079	-1.228	-0.308	0.681	0.284	-2.323
SectorFocus	SF	0.488	0.434	0.079	1.228	**0.923**	2.044	0.284	2.323
Proximity to knowledge source: Arms-Length	X5_AL	-0.895	1.166	0.2	-1.95	-0.21	0.085	0.011	-0.458
Proximity to knowledge source: Independent	X5_I	**0.915**	3.048	0.837	3.987	0.221	0.234	0.049	0.962
Proximity to knowledge source: Inhouse	X5_InH	-0.928	1.883	0.369	-2.648	-0.228	0.149	0.022	-0.65
Locus of governance: Autonomous	X6_A	**0.942**	2.588	0.592	3.354	0.258	0.256	0.045	0.92
Locus of governance: Prescribed	X6_P	-0.747	2.031	0.557	-3.254	-0.061	0.018	0.004	-0.268
Locus of governance: Semi	X6_S	-0.037	0.001	0	-0.053	-0.726	0.506	0.059	-1.055
Salary: Gov	X7_G	0.671	0.655	0.112	1.462	**1.468**	4.134	0.539	3.199
Salary: Knowledgesource	X7_KS	-0.915	3.048	0.837	-3.987	-0.221	0.234	0.049	-0.962
Salary: RevIncome	X7_RI	**1.077**	2.537	0.497	3.074	-0.611	1.074	0.16	-1.743
Facilities: Gov	X8_G	0.671	0.655	0.112	1.462	**1.468**	4.134	0.539	3.199
Facilities: Independent	X8_I	**1.077**	2.537	0.497	3.074	-0.611	1.074	0.16	-1.743
Facilities: Knowledge Source	X8_KS	-0.915	3.048	0.837	-3.987	-0.221	0.234	0.049	-0.962
Fin: Gov	X9_G	0.671	0.655	0.112	1.462	**1.468**	4.134	0.539	3.199
Fin: Knowledge Source	X9_KS	-0.915	3.048	0.837	-3.987	-0.221	0.234	0.049	-0.962
Fin: Shareholders	X9_S	**1.077**	2.537	0.497	3.074	-0.611	1.074	0.16	-1.743
Background IP: knowledge creator	X10_KC	-0.06	0.023	0.032	-0.781	-0.318	0.876	0.913	-4.164
Background IP: KTI	X10_KTI	0.537	0.21	0.032	0.781	**2.866**	7.88	0.913	4.164
Foreground IP: knowledge creator	X11_KC	-0.06	0.023	0.032	-0.781	-0.318	0.876	0.913	-4.164
Foreground IP: KTI	X11_KTI	0.537	0.21	0.032	0.781	**2.866**	7.88	0.913	4.164
Revenue Ownership: knowledge creator	X12_KC	-0.628	1.726	0.592	-3.354	-0.172	0.171	0.045	-0.92
Revenue Ownership: KTI	X12_KTI	0.52	0.098	0.014	0.52	**3.017**	4.367	0.479	3.017
Revenue Ownership: shared	X12_S	**1.003**	2.564	0.541	3.207	-0.136	0.062	0.01	-0.434
Ownership of Metrics: knowledge creator	X13_KC	-1.099	3.521	0.805	-3.912	-0.18	0.124	0.022	-0.639
Ownership of Metrics: KTI	X13_KTI	**0.733**	2.347	0.805	3.912	0.12	0.083	0.022	0.639
Unit of Performance & Reporting: knowledge creator	X14_KC	-1.099	3.521	0.805	-3.912	-0.18	0.124	0.022	-0.639
Unit of Performance & Reporting: KTI	X14_KTI	**0.853**	2.387	0.596	3.364	0.163	0.114	0.022	0.641
Unit of Performance & Reporting: other	X14_O	0.371	0.151	0.024	0.68	-0.009	0	0	-0.017
Foresight and diagnostics: not undertaken	X15_NU	-0.045	0.012	0.008	-0.393	-0.31	0.738	0.385	-2.704
Foresight and diagnostics: undertaken	**X15_U**	0.18	0.047	0.008	0.393	**1.241**	2.953	0.385	2.704
Scanning and information processing: not undertaken	X16_NU	-1.094	3.051	0.644	-3.498	-0.19	0.121	0.019	-0.607
Scanning and information processing: partial	X16_P	0.355	0.321	0.068	1.134	-0.473	0.75	0.12	-1.512
Scanning and information processing: undertaken	X16_U	0.862	1.626	0.319	2.461	0.773	1.719	0.256	2.206
Knowledge processing, generation and combination: Creation/ Dissemination / Diffusion	CDD	0.14	0.007	0.001	0.14	-0.604	0.175	0.019	-0.604
Knowledge processing, generation and combination: Creation/ Dissemination / Diffusion / Adoption	CDDA	**0.98**	0.35	0.051	0.98	-0.71	0.242	0.027	-0.71
Knowledge processing, generation and combination: Creation/ Dissemination / Diffusion / Adoption / Capitalisation	CDDAC	-0.69	1.736	0.477	-3.009	0.481	1.111	0.232	2.098
Knowledge processing, generation and combination: Dissemination / Diffusion	DD	**0.632**	0.582	0.1	1.377	-0.37	0.263	0.034	-0.807
Knowledge processing, generation and combination: Dissemination / Diffusion / Adoption	DDA	**0.814**	0.965	0.166	1.774	-0.505	0.489	0.064	-1.1
Network building: partial	X18_P	**0.86**	0.809	0.131	1.575	-0.341	0.168	0.021	-0.625
Network building: undertaken	X18_U	-0.152	0.143	0.131	-1.575	0.06	0.03	0.021	0.625
Contracts: issuer	X19_I	-0.538	1.162	0.354	-2.595	0.373	0.734	0.17	1.797
Contracts: user	X19_U	0.658	1.42	0.354	2.595	-0.456	0.897	0.17	-1.797
Crowdsourcing: instigator	X20_I	0.791	0.456	0.07	1.15	-0.521	0.26	0.03	-0.757
Crowdsourcing: referrer	X20_R	-0.088	0.051	0.07	-1.15	0.058	0.029	0.03	0.757
Crowdsourcing: not undertaken	X21_NU	0.755	1.453	0.307	2.414	-0.452	0.687	0.11	-1.447
Testing, validation and training: partial	X21_P	-0.578	1.339	0.408	-2.785	-0.233	0.287	0.067	-1.124
Testing, validation and training: Undertaken	X21_U	0.537	0.21	0.032	0.781	**2.866**	7.88	0.913	4.164
Accreditation and standards: Contributor	X22_C	-0.941	2.905	0.725	-3.711	-0.121	0.063	0.012	-0.476
Accreditation and standards: Issuer	X22_I	0.537	0.21	0.032	0.781	**2.866**	7.88	0.913	4.164
Accreditation and standards: not undertaken	X22_NU	**0.822**	2.215	0.553	3.24	-0.516	1.151	0.218	-2.036
Regulation and arbitration (Dispute resolution): leader	X23_L	-0.8	2.331	0.64	-3.487	0.498	1.189	0.248	2.17
Regulation and arbitration (Dispute resolution): not undertaken	X23_NU	**1.071**	2.091	0.383	2.696	-0.343	0.281	0.039	-0.862
Regulation and arbitration (Dispute resolution): referrer	X23_R	0.529	0.509	0.093	1.33	-0.653	1.023	0.142	-1.643
IP management: not undertaken	X24_NU	**0.802**	1.875	0.429	2.855	-0.492	0.929	0.161	-1.751
IP management: partial	X24_P	**0.98**	0.35	0.051	0.98	-0.71	0.242	0.027	-0.71
IP management: undertaken	X24_U	-0.672	1.812	0.553	-3.24	0.422	0.941	0.218	2.036
Commercialisation: not undertaken	X25_NU	0.801	1.404	0.275	2.287	-0.679	1.328	0.198	-1.938
Commercialisation: partial	X25_P	-0.49	1.051	0.361	-2.617	-0.138	0.11	0.029	-0.737
Commercialisation: exploiting the outcomes: Undertaken	X25_U	0.537	0.21	0.032	0.781	**2.866**	7.88	0.913	4.164
Assessment and evaluation: not undertaken	X26_NU	0.822	2.215	0.553	3.24	-0.516	1.151	0.218	-2.036
Assessment and evaluation: partial	X26_P	-0.941	2.905	0.725	-3.711	-0.121	0.063	0.012	-0.476
Assessment and evaluation: Undertaken	X26_U	0.537	0.21	0.032	0.781	**2.866**	7.88	0.913	4.164

Appendix 4. Categorical variables against the dimensions



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