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The new inclusive role of university technology transfer: Setting an agenda for further research

Dwitya K. Amry^{a, b, *}, Ali J. Ahmad^a, Dawei Lu^a

^a WMG, University of Warwick, Coventry, CV4 7AL, UK

^b Faculty of Economics and Business, Universitas Nasional, Jakarta, Indonesia

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ABSTRACT

Universities are coming under increasing pressure to produce impact that contributes to socio-economic development. Previous studies have focused on university technology transfer (UTT) mechanisms that lead to the commercialisation of intellectual property. We find that off-late, the legitimacy of such mechanisms, owing to high-failure rates of IP-based start-ups, has come into question. Universities are being invited to widen their academic entrepreneurship (AE) practices to include other forms of knowledge transfer. The increased attention on contemporary concepts such as social entrepreneurship calls for broadening UTT performance indicators to include multiple bottom-lines. These bottom-lines should amplify the *societal benefits* of AE. This new emphasis raises high-level questions about the societal role of universities and UTT. The aim in this paper is to, therefore, reframe the debate on UTT processes by highlighting a revised agenda for further research. This is done by analysing the extant literature on UTT, academic entrepreneurship, entrepreneurial universities and innovation. The analysis includes a critical review of 96 peer-reviewed articles. As a result, a macro perspective is presented which highlights UTT as-a-mechanism for universities' contribution to collective societal goals. Propositions are outlined for future research; these can be used for developing new understanding on how universities can actively contribute to socio-economic development agendas.

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1. Introduction

The emphasis in research on university technology transfer (UTT) has been on highlighting the value of licencing intellectual property (IP) to technology commercialisation agendas (Algieri et al., 2013; Vinig and Lips, 2015) and as a mechanism for promoting academic entrepreneurship (AE) (Wright and Filatotchev, 2014; Siegel and Wright, 2015). Viable 'commercial performance' of science and technology research outputs is most often viewed as UTT 'success' (Abreu and Grinevich, 2013; Vinig and Lips, 2015; Seno Wulung, Takahashi and Morikawa, 2018). To contemporary researchers in social innovation and social entrepreneurship, this is problematic (Corsi et al., 2020). They call for organisations, including universities, to operate

* Corresponding author. WMG, University of Warwick, Coventry, CV4 7AL, UK.

E-mail address: d.amry@warwick.ac.uk (D.K. Amry).

using 'hybrid' approach which gives equal importance to profitability, sustainability and accountability (Carayannis and Papadopoulos, 2011; Siegel and Wright, 2015).

Calls are being made to re-think the taken-for-granted-ness of universities' role in society. The present socio-economic and health crisis owing to COVID-19, and the poverty and climate change narratives question university agendas on linking science and technology research with commercial gain. There is now mounting pressure on universities by institutions such as the United Nations to demonstrate contribution to global challenges as captured in their sustainable development goals (Corsi et al., 2020). Now, 'society' should be viewed as an important stakeholder in the UTT process (Miller et al., 2016; Franco-Leal et al., 2020). A transition is, therefore, occurring from the Triple Helix to the Quadruple Helix to alter UTT mechanisms. As a part of universities' new 'third mission', there is need to explain the socio-economic impact of the technology transfer and commercialisation processes (Hofer and Potter, 2009; Abreu et al., 2016; Corsi et al., 2020).

Technology transfer researchers have argued that academic entrepreneurship (AE) contributes by default to socio-economic development through innovation (Abreu and Grinevich, 2013; Perkmann et al., 2013; Abreu et al., 2016; Budyldina, 2018; Chin et al., 2019). However, there is a problem in this link - universities often equate their contributions to building regional innovation systems as socio-economic development, when in effect this is a false equivocation (Cinar and Benneworth, 2020). Solving pressing challenges in society requires the use of a new approach and the creation of different structural conditions which are not fully reflected in the UTT process (Arocena et al., 2018).

This paper responds to the invitation by Siegel and Wright (2015) to reconceptualise the term 'academic entrepreneurship'. They argue that the narrow focus in AE research on 'formal' UTT activities such as IP generation and capitalisation of research does not capture the broader entrepreneurial activities that universities regularly engage in. Specifically, with the rise of interest in social innovation and entrepreneurship on university campuses, there is a unique possibility that AE and its accompanying UTT mechanism may be able to incorporate 'other' forms of innovation, beyond science and technology research outputs, that are more *inclusive* (Cozzens and Sutz, 2014; Bryden et al., 2017). Our premise is that, to facilitate universities' third mission, AE must be re-conceptualised as a mechanism to facilitate 'other' types of innovation. In this study, we label these 'other' innovations - societal-based innovations (Barbour and Luiz, 2019).

In this paper, by taking a macro- and meso-perspective, a clear rationale is first presented for the needed refocus in UTT mechanisms research to enable societal-based innovation. Second, through a critical review of previous literature, the main research themes within the area of UTT mechanisms for societal based innovation are delineated and distilled. This leads to a new framework to better understand how universities can contribute *inclusively* to socio-economic development through their various types of research outputs, not just science and technology-based. We outline the background of our study in the next section.

2. Background literature

2.1. UTT as a mechanism for academic entrepreneurship

Research on AE conceptualises it as a process for the commercialisation of intellectual property generated from university research, where research outcomes must be patent-able, and demonstrate market potential and economic value (Campbell and Güttel, 2005; Shane, 2014; Morcolonggo, 2017). The rationale behind this view is that economic value gained from the commercialisation of research would be put back into the university to conduct more research. The performance indicators universities used to evaluate UTT effectiveness tend to skew on how much income the commercialized technology generated. Fig. 1 depicts this formal mechanism for the transfer of university research via AE.

Informed by Abreu and Grinevich (2016), in this paper AE is conceptualised as activities that go beyond traditional academic roles and boundaries. Traditional academic roles are understood as teaching and research, whereas traditional academic boundaries are universities and scientific communities. Those academics who step beyond these boundaries are considered to be dwelling in AE (Miller et al., 2018). Specifically, AE is about marketing research ideas or research-based products to generate individual or institutional benefit in the form of profit, influence, or prestige (Louse et al., 1989). This definition does not limit AE to IP-based income generation initiatives such as spin-out creation or licensing deals, but also other overarching mechanisms that encompass knowledge sharing. Such mechanisms might not directly generate profits for universities, but would increase social value in differentiating ways for the involved individual or institutional stakeholders.

UTT should be viewed as a mechanism for promoting AE. A mechanism is defined as 'causal chains linking all elements involved in constituting a social fact' (Demeulenaere, 2012, p. 12). Using a mechanism-based lens allows us to not only to anticipate events, but also capture the rationales for why these events occur in the first place. Understanding UTT-as-a-

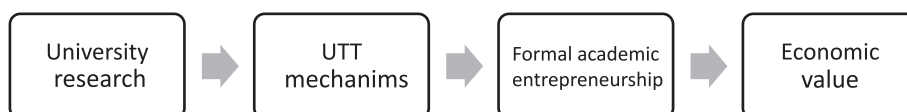


Fig. 1. UTT for economic value.

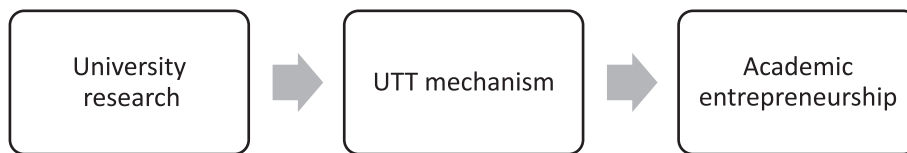


Fig. 2. UTU as a mechanism.

mechanism allows us to build an explanation of *how* universities could facilitate AE's broadening practices (see Fig. 2). Simply put, once overarching UTU mechanisms are adopted, then it can be said that AE is occurring within a university.

2.2. The incomplete role of Technology Transfer Offices

UTT is enacted through intermediary institutions within universities, such as Technology Transfer Offices (TTO), also known as Business Engagement or Innovation Offices etc. These establishments focus on protecting research outputs in the form of patents, and assess the commercial value of innovations stemming from academic research (Lowe, 2006; O'Kane et al., 2015). University research outputs are treated as resources to be leveraged to generate income via entrepreneurship (Vinig and Lips, 2015). Within this perspective, the key determinant for AE commercialisation 'success' is that the ownership of university research outputs must be unambiguously protected (through IP instruments). Without IP ownership such as patents, tangible commercial value, it is assumed, cannot be reaped.

Other roles of TTOs include the preparation of documentation to ensure all parties involved in UTU benefit. Their role also includes sourcing suitable commercial partners or work with universities' internal entrepreneurship promotion mechanisms such as Science Parks, Incubators or Accelerators to create new firms around patented technology (Good et al., 2018).

However, Goel and Göktepe-Hultén (2018) point out that TTOs often miss out on the opportunity to transfer and commercialise non-patent type of university research. Aldridge and Audretsch (2010) found that 30% of university scientists would choose to bypass the TTO if they saw potential for the creation of new firms instead of licensing patents to incumbent firms. Additionally, intellectual property is mainly granted based on novelty and goes through a long and lengthy process to secure protection (Goel and Göktepe-Hultén, 2018). These problems withhold opportunities, waste valuable university resources and risk the underutilisation of a university's overall research output potential.

Fini et al. (2018) invite us to rethink the commercialisation of research problem; in that we must not only assess research's 'market value', but also its 'social value'. Unfortunately, TTOs' mandate and institutional arrangement make them ill-equipped to view university research from a 'social value' perspective (Vinig and Lips, 2015; Good et al., 2018). University research is generated by various disciplines such as the physical sciences, engineering, medicine or social sciences, arts and humanities. The focus of UTU on only commercialising 'patent-able' science and technology research divorces them from the possibility of creating 'social value' from intangible but solution-driven outputs from the humanities or arts disciplines (Abreu and Grinevich, 2013; Cinar and Benneworth, 2020). Some science and technology research outputs which might have the potential to solve a pressing societal issue, but may not be novel enough to be patented, may be overlooked by TTOs (Clarysse et al., 2011). In this manner, universities can miss out on opportunities to demonstrate positive socio-economic contributions mandated within their 'third mission' agendas.

2.3. University research for socio-economic development

Studies stemming from higher education research posit that universities are "home to a range of disciplines which have detailed understandings of the kinds of problems, and the potential solutions to those problems, faced by excluded communities." (Benneworth, 2013, p. 21). As a part of this view, there is an emerging stream of UTU research that posits the ways universities can contribute to socio-economic development through innovation (OECD, 2004; Yusof and Jain, 2010; Hayter, 2013; Payumo et al., 2014; Miller et al., 2016; Carayannis et al., 2018; Gianiodis et al., 2019; Cinar and Benneworth, 2020). To understand the manner in which universities can contribute to socio-economic development, we highlight two major streams within extant innovation research which can be distinguished based on *intention* and *objectives*.

The *first* stream of innovation research relies on the concept of 'disruptive innovation' (Boni et al., 2018) which leads to commercial products or services (Algieri et al., 2013) capitalising on novelty for monetary gain. Disruptive innovation is typically enacted by corporations whose main mission is to maximize shareholder value. Societal benefits are not the main goal, and are usually a by-product which diffuse through macro-level innovation systems (Bradley et al., 2013; Acs et al., 2017). Building on the Schumpeterian school of thought, researchers in this stream assume that conditions are optimal, robust innovations systems are in place and that resources for innovation are in abundance (Rasmussen and Borch, 2010; Cozzens and Sutz, 2014; Wright, 2014; Vinig and Lips, 2015). The main view held is that disruptive innovations are in some way ground-breaking and imbued with new technology benefiting from the first-mover's advantage to exploit innovation for financial gain.

However, scholars on innovation have started to pay attention to the kinds of innovation that could be harnessed for solving the pressing challenges outlined in the UN's sustainable development goals (Neal, 2017; Corsi et al., 2020). Hence, the

second stream focuses on inclusive and pro-society innovation (Fini et al., 2018) or innovation which diverges away from the Schumpeterian school-of-thought (Brem and Wolfram, 2019). Such innovations, by design, focus on societal benefit from the very onset. The goal is to portray social impact either on top of or equal to financial impact. It typically involves design which considers socio-commercial opportunities stemming from pressing problems in society. Innovation emerges as an attempt to create solutions to such problems (McKelvey and Zaring, 2018; Franco-Leal et al., 2020). These solutions may also be technology-based, but their goal is not to leverage on the novelty of the technology for mere financial gain, but to use technology as a means to address specific societal challenges or objectives (Fisher et al., 2006). Pro-societal types of innovation include jugaad or frugal innovation, frugal engineering, constraint-based innovation, Gandhian innovation, catalytic innovation, grassroots innovation, indigenous innovation, and reverse innovation (Brem and Wolfram, 2019). Such types are mostly prevalent in environments with high institutional voids and resource scarcity (Bhatti, 2012).

To understand the role of the university in promoting socio-economic development through pro-societal innovation, we must first re-consider the aims of AE. As outlined by Abreu and Grinevich (2013, p. 401): "... academic entrepreneurship can encompass activities that result in an increase in social welfare, and leads to positive organisational or societal changes, in addition to achieving financial rewards for the entrepreneur". This egalitarian view of AE can, therefore, include facilitating other types of 'non-patentable' innovation that focuses on social value alongside economic value. However, the question lies: do (or even 'can') existing UTT mechanisms accommodate this new view of academic entrepreneurship, which is in line with universities' third mission? It is still very much unclear how UTT mechanisms can be used to facilitate the academia's contribution to socio-economic development agendas.

2.4. A way forward

Following on from the previous sections, we propose two questions which require further critical investigation: 1) "How has existing UTT research addressed the new requirement for universities to more explicitly demonstrate contributions to socio-economic development agendas?" and "How will this new requirement within universities' third mission alter existing UTT mechanisms?". We posit that the requirement to demonstrate contribution towards socio-economic development agendas on the part of universities is often implicit and taken-for-granted. Our aim is to make this requirement more visible and viable. This is done by developing a framework that can be used as a rationale for driving further UTT research which aims to shed light on the question: how universities can better facilitate socio-economic development?

3. Mode of inquiry

In this paper, the systematic review method is followed as the overall aim is to investigate a particular problem in *practice* (Tranfield et al., 2003). We build our study on the intersections of literature relating to university technology transfer, academic entrepreneurship and higher education as it relates to the 'entrepreneurial university' concept. Since the focus is on aspects that enable UTT to address multiple bottom lines through societal-based innovation, papers were also drawn from the 'inclusive innovation' body-of-work to understand emerging debates. As our topic is considered mature (Wright, 2014), we follow the integrative review method introduced by Torraco (2005), who defined it as "a form of research that reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated" (p.1).

We assess the literature using a critical theory approach under a mechanisms-based lens to uncover inconsistencies in the way universities' role in socio-economic development through UTT is portrayed. Fig. 3 portrays our analytical framework.

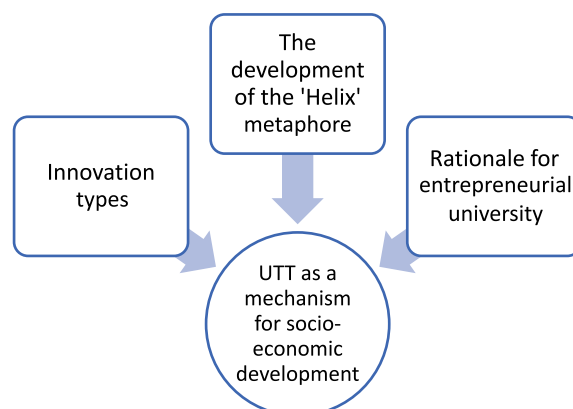


Fig. 3. Analytical framework.

Table 1
Review protocol.

Stage	Objective	Inclusion/Exclusion Criteria	Quality Appraisal and Audit	Outcome from the stages
Stage 1	To search for and identify seminal articles To determine research themes and conceptual framework	Articles ranging from 1990 to 2019 Top 20 journals identified from Kraus et al. (2020) and research policy	Read the title to scan for relevancy with research question	Academic entrepreneurship broadening practices Entrepreneurial university The “Helix” metaphor 246 articles
Stage 2	Search for keywords ‘academic entrepreneur’ and ‘university technology transfer’ and ‘Innovation’ Research question: How can universities better facilitate socio-economic development?	Top journals from the ABS ranking (appendix)		
Stage 3			Reading the title and abstract for relevancy	108 articles
Stage 4	Data extraction	Access problems Inclusion of seminal articles		96 articles
Stage 5	Analysing data from sources			Standardised table format

The analysis is organized along three key themes: (1) the changing narrative within the entrepreneurial university rationale (2) the further development of the Helix structure and (3) the broadening practices of AE within universities to include a wider range of innovation types. In line with [Torraco's \(2016\)](#) suggestions on the use of the integrative review method, in order to critically analyse existing research and pinpoint inconsistencies, the adopted approach is to challenge current UTT research to raise new debate on the university's role in addressing societal-challenges.

3.1. Review protocol

Our review was done in five stages (see [Table 1](#)). The first stage was planning the literature review. We followed the protocol outlined by [Kraus et al. \(2020\)](#) and undertook keyword searches on Google Scholar to discover articles on university technology transfer, academic entrepreneurship, and the entrepreneurial university. Intersections of these topics were discovered which ultimately became our research themes (see [Table 2](#)). We also identified combinations of keywords which would uncover intersections between UTT, AE and socio-economic development. The keywords we used included terms such as: ‘university technology transfer’, ‘academic entrepreneurship’, ‘academic engagement’, ‘academic impact’ combined with ‘innovation’, ‘entrepreneurial university’, ‘triple helix’, ‘economic development’, ‘social development’.

The second stage was article search on Scopus using the identified keywords as search strings. We limited our work based on publication date and journal quality. Based on earlier work done by [Miller et al. \(2018\)](#), only peer reviewed articles from 1990 to 2019 were included in the review as the year 1990 is marked as the period where research in our three themes ‘took-off’. We only included articles published in journals with a JCR impact factor above the score of 2 to ensure quality. Journal categories were selected from the ABS/Academic journal quality guide which pinpointed category specific journals in the areas of Entrepreneurship, Innovation and Higher Education. This stage resulted in the discovery of 246 articles.

In the third stage, articles were scanned based on their titles and abstracts to ensure relevance to the research topics. This reduced the number of initially discovered 246 articles to 108. Then, all these 108 articles were downloaded in full-text format. In the fourth stage, data was extracted from these papers using a standardised format ([Tranfield et al., 2003](#)). In

Table 2
Themes.

No	First order Themes	Second order themes	For example in:
1	Rationale for entrepreneurial university	Capitalisation of knowledge Democratisation of knowledge	Fini et al. (2010) ; Wonglimpiyarat (2010) ; Vinig and Lips (2015) ; Murray and Stern (2016) ; Belitski et al. (2019) ; Rippa and Secundo (2019)
2	The Helix structure	Triple Helix	Benneworth and Jongbloed (2010) ; Carayannis and Campbell (2011) ; Abreu and Grinevich (2013) ; Guerrero et al. (2015) ; Schaeffer and Matt (2016) ; Halilem et al. (2017) Etzkowitz (2003) ; Arapostathis (2010) ; Van Looy et al. (2011) ; O’Kane (2018) ; Heaton et al. (2019)
3	Innovation types	Extension to Quadruple and Quintuple Helix UTT for technological innovation UTT for societal based innovation	Carayannis and Campbell (2012) ; Colapinto and Porlezza (2012) ; Martin (2012) ; Miller et al. (2014) ; Carayannis et al. (2018) Breznitz, O’Shea and Allen (2008) ; Han and Niosi (2016) ; Thomas et al. (2020) ; Markman and Gianiodis, et al. (2005) ; Markman and Phan, et al. (2005) ; Breznitz, O’Shea and Allen (2008) ; Haeussler and Colyvas (2011) ; Algieri et al. (2013) ; Hayter (2016) Perkmann et al. (2011) ; Walshok, Shapiro and Owens (2014) ; Fini et al. (2018) ; McKelvey and Zaring (2018) ; Cinar and Benneworth (2020)

retrospect, a few specific articles, book chapters and papers were included - if there were at least 2 previously identified articles making a reference to its content. This was done to ensure that seminal ideas on the chosen topics were duly included in this study. Through data extraction and skimming, a number of articles were deemed irrelevant to our research aim, and therefore excluded. This led to a total of 96 studies included as a sample in this paper.

At the final stage, selected articles were critically analysed based on the predetermined conceptual framework, which led to the creation of second order themes presented in [Table 2](#). We used these themes to extract and critically analyse the sample literature.

4. Findings and analysis

4.1. *The entrepreneurial university: rationale for transfer of technology*

Universities are labelled either teaching-led, research-led or entrepreneurial ([Abreu et al., 2016](#); [Dalmarco et al., 2018](#)) based on the aggregation of the function they play in society. Technology transfer (TT) is seen as a process of commercialising universities' research for impact through advancements in knowledge, community engagement and innovation ([Aldridge et al., 2017](#)). It is understood that in a university's research commercialisation activity, knowledge that is embedded in research is capitalised upon ([Etzkowitz, 1997](#)), and universities that dwell in such activities are deemed 'entrepreneurial' ([Zhou, 2014](#)). The term 'commercialisation' has been widely used as a mechanism for TT that results in some form of monetary outcome ([Wright et al., 2012](#)). This mechanism is formalised through the disclosure of an academic's invention to the university. Simply put, in formal forms of UTT, universities would protect their research output in the form of intellectual property which will then be 'sold' to industries or end-users. The profit generated from this activity is often assumed to be invested back into universities for funding further research.

4.2. *Entrepreneurial universities through capitalisation of knowledge*

Research in the area of knowledge production and TT has led to a debate on what research commercialisation by academics or scientists really entails, inviting a reconceptualization of the term 'commercialisation' and questioning the construct of the 'entrepreneurial university' concept ([Guerrero et al., 2015](#); [Abreu et al., 2016](#); [Skute, 2019](#)). To unpack these two terms, we turn to Gibbons et al.'s (1994) work. They suggested that activities universities conduct can be categorised into different modes – *Modes 1, 2 and 3*. *Mode 1* is related to the university's basic activity. In *Mode 1*, knowledge is produced and consumed internally within the university for teaching and basic discipline-based research. Knowledge is disseminated through publications which then enhances teaching materials.

In *Mode 2*, universities become a hub of innovation ([Schaeffer and Matt, 2016](#)), where research resulting in technological innovation is further developed through UTT. In this mode, industries and markets influence the knowledge production process which aims to produce research that can be applied to industry and where knowledge is capitalised upon ([Wonglimpiyarat, 2010](#); [Carayannis and Papadopoulos, 2011](#); [Murray and Stern, 2016](#)). *Mode 2* UTT activities are geared to commercialisation ([Martin, 2012](#); [Aldridge and Audretsch, 2017](#)). The underlying reason for aiming for commercialisation is the assumption that academics will be more inclined to undertake TT activities if there is a clear incentive ([Lakitan et al., 2012](#)) and that universities will facilitate TT activity if it is financially profitable for them ([D'Este and Perkmann, 2011](#); [Lauto et al., 2013](#)).

The rationale of why UTT is used as a mechanism for capitalising on knowledge is twofold. First, from a university's perspective, as research funding is becoming increasingly scarce, universities need to look for alternative income to be invested into more research ([Murray and Stern, 2016](#)). Therefore, universities capitalise on their knowledge and develop technologies that are commercially attractive to draw industry's funds. These are done through licensing their intellectual property, creation of spin-offs around their technology, joint commercial research with industrial partners, and consultancy. Such activities enable steady income independent of government funding ([Murray and Stern, 2016](#); [Guerrero and Urbano, 2017](#)). Secondly, through a firm's perspective, innovation is imperative for growth and survival. However, the cost and risk associated with developing new technology is quite high ([Donaldson and Wickerham, 2012](#); [Rajalo and Vadi, 2017](#)). To lower the risk and cost associated with innovating, firms look beyond their internal resources for innovation. Universities are perceived as hotbeds for new inventions through their research capabilities, thus they become the primary source of firms for innovation.¹ This creates a supply-demand relationship between firms and universities.

These two dominant assumptions were deemed incomplete especially in terms of universities' third-mission mandate which requires a clear demonstration of contribution to the betterment of society ([Carayannis and Campbell, 2011](#)). Universities are viewed as institutions where philosophers, theorists and scientists in multiple disciplines came together to understand the world in order to help an 'ideal society'. Thus, it is argued that universities' knowledge and research output should be reinforced and realigned such that their contribution towards this higher-level aim is actualisable ([Arocena et al.,](#)

¹ We recognise the simplicity of this premise but argue that this portrays the assumptions behind most university technology transfer theories. But we do not in any way discount the complexity behind university-industry partnership initiatives.

2018). This does not mean that universities should not be innovative and benefit from their inventions; UTT needs to better capture their true role in society where new knowledge created ought to be used for societal benefit.

'Knowledge exchange' activities are labelled as *Mode 3* (Carayannis and Campbell, 2012; Miller et al., 2016). When technology ownership cannot be claimed by the university (through intellectual property, for example), technology in the form of the academic scientist's tacit knowledge can be transferred through public lectures and informal advice (Abreu and Grinevich, 2013). This claim is also supported by Miller et al. (2018), who argued that even though academic scientists may not formally commercialise their research, they can still be recognised as transferring technology through knowledge exchange activities. Even though there are no direct economic returns, Abreu and Grinevich (2013) argue that *Mode 3* activities will impact universities' economic value through building reputation, prestige and social benefit which can influence the likelihood of commercialisation of other forms of knowledge in the future.

The above conceptualization of *Mode 3* allows universities to support TT activities with unclear financial outcomes, arguing for the need to consider other outcomes such as 'social impact' (Siegel and Wright, 2015).

4.3. Entrepreneurial universities through democratisation of knowledge

Although a large volume of research has been published on research commercialisation through UTT, it often focuses on market factors to assess the effectiveness of various models (Cunningham et al., 2019) and not so much on the impact it has on society (Siegel and Wright, 2015; Budyldina, 2018). These studies are positivist in nature, measure the *quantity* of research commercialisation outputs as an indicator of performance and have devoted attention on aligning UTT with the 'traditional' conceptualization of AE (Vinig and Lips, 2015; Cunningham et al., 2017). As 'social impact' is now increasingly legitimised as a performance indicator (Murray and Stern, 2016; Sandström et al., 2018), it is argued that the *quality* of research commercialisation activities also needs to be addressed based on the premise of how it benefits society (Siegel and Wright, 2015; Fini et al., 2018). This notion of 'quality' requires a reconceptualization of UTT that accommodates a wider definition of AE.

In order to redefine AE's overall purpose, we must first understand how universities align commercialisation activities with other forms of impact besides the financial bottom line. Although not explicitly clear, some research infers that interactions and engagement with society will influence commercialisation activities and impact outcomes. However, problematically, such impact is often touted as a by-product instead of an *end-product*. For example, commercialisation may result in the advancement of knowledge (Audretsch and Link, 2018; Heaton et al., 2019) or social development through education (Wright, 2014). It has been argued that the commercialisation of research that includes user-stakeholders in the process of TT may result in community interaction with universities to co-produce knowledge with society (Gofen, 2015; Miller et al., 2016; Chin et al., 2019). This allows social impact to be perceived not just as a by-product, but side to side with financial impact. For example, there are cases where an opportunity to innovate is sourced from real challenges faced by society as the user-stakeholders. This can lead towards indigenous innovation that is more relevant to the community it intends to serve (Lakitan, 2013; Bruton et al., 2018).

From the above, it can be surmised that universities can be viewed as entrepreneurial by evaluating where their innovation opportunities are sourced from and what the intended result is. Thus, universities could address social impact not only as a by-product, but as an indicator bearing considerable significance alongside other indicators within the AE agenda. This new and holistic view of AE and 'impact' will influence the nature of the UTT mechanisms deployed by universities.

4.4. The structure of UTT: helix metaphors

We have explained the traditional role of universities in society - to produce universal knowledge that will increase society's wisdom (Benneworth and Jongbloed, 2010; Urbano and Guerrero, 2013). Whereas, the industry's role is to become the economic engine of society. While government ensures prosperity and justice for all societal members.

However, boundaries between the above differentiated roles are becoming blurry (Etzkowitz, 1997). For example, in pre-starting up, government issues calls-for-action in certain areas to stimulate research activities by universities. Government takes the role of funder in calling for proposals and assesses which research projects are high potential. Then, universities take the role of enterprises to compete with other universities to receive those funds. To gain legitimacy to carry out 'enterprising' roles, universities often partner with industry to ensure viability and applicability of research. Then, industries take on the role of universities to conduct research on emerging technologies to increase their competitiveness. This activity of 'taking the roles of the other', means that different institutional spheres constantly intertwine and are involved in boundary spanning activities, thus conceptualised as helices (Etzkowitz and Leydesdorff, 1997). To date, research has outlined three main helix metaphors, the Triple Helix, Quadruple Helix and Quintuple Helix. Fig. 4 visualises how the helix metaphor has extended over the years.

The helices metaphor views the university, industry and government complex as a necessary basis to drive innovation, which ultimately leads to a knowledge-based economy (Etzkowitz and Leydesdorff, 1997; Etzkowitz and Zhou, 2017). There are two main reasons why governments actively invest in university-private sector TT partnerships. First, investments are made on the assumption that industries are hesitant to pursue innovation because the process is seen as a liability with high-failure risks and market uncertainty (Fudickar and Hottenrott, 2019). Therefore, governments take on the role of investing funds, at least initially, to de-risk the innovation process. Second, governments invest in TT partnerships because economic

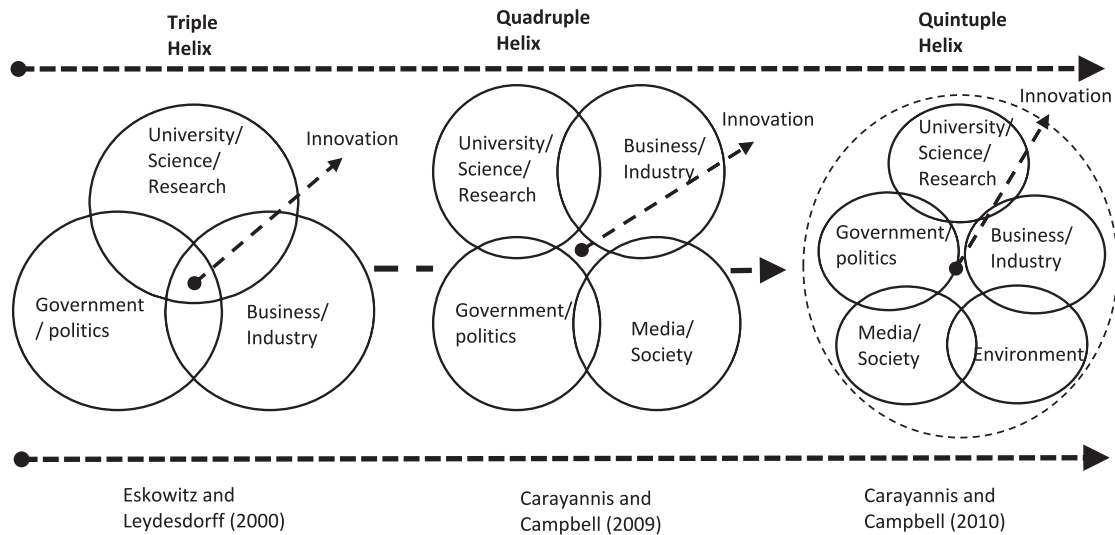


Fig. 4. The Helix Structure influence on innovation (Adapted from Barth and Schlegelmilch (2013).

development is achieved through the creation of robust and sustainable growth-based firms which grow out of university-private sector TT partnerships (Algieri et al., 2013; Fishman, O'Shea and Allen, 2014; Dalmarco et al., 2018; Sandström et al., 2018). It is assumed that such firms drive employment generation and increase regional competitiveness (Dalmarco et al., 2018).

TH studies use organisational theory (Wong et al., 2014; Etkowitz and Zhou, 2017) to map out multi-sectoral interactions and cooperation that drive innovation (Mustar et al., 2014). The assumption is that the roles of these different actors – public, private and academic merge to co-innovate. Studies on these interactions look at boundary spanning activities (Siegel et al., 2004), resources utilisation (Fudickar and Hottenrott, 2019), capabilities and competencies pooling (Heaton et al., 2019) to model failure risks and suggest means to enhance partnership outputs.

Within the Triple Helix concept, innovation is portrayed as a linear process, where the activity includes basic research, applied research, valuation of IP, marketing of IP and diffusion in industry (Kline, 2009). University research is categorised as innovation if it has been diffused to industry and creates value in the form of a firm's competitive advantage enhancement (Audretsch and Caiazza, 2016). The value ascribed to innovation within the Triple Helix scheme is *profitability*. This notion has sparked the debate on universities' role on capitalising on knowledge that should have been shared freely which we have outlined in section 4.3.

4.5. Extensions to Triple Helix

The Quadruple Helix and the Quintuple Helix serve as extensions of the Triple Helix (see Fig. 4). These extensions it has been argued can better capture universities' 'third mission' beyond research and teaching (Carayannis and Campbell, 2012; Barth and Schlegelmilch, 2013; Carayannis et al., 2018). In both the Quadruple and Quintuple Helix, additional institutions are included, which are 'society' within the Quadruple Helix, and 'ecological environment' within the Quintuple Helix.

Triple Helix proponent's claims that 'society' and the 'environment' are the underlying reasons for universities-industries-government alliances are setup in the first place. However, Carayanis and Campbell (2012) argue that this is simply not enough; the role of 'society' and the 'environment' must be made more explicit. Society and the ecological environment need to become active participants in the innovation process. Nevertheless, with the TH laying on top of the assumption of innovation linearity, Quadruple Helix recognises the nonlinearity of innovation. It takes an ecosystem perspective and builds on the assumption that innovation process are networked. Thus, based on this premise, innovation within a Quadruple Helix structure explicitly includes 'society' in the process of co-creation, to validate relevancy and accountability (Miller et al., 2016). Along these lines, Quintuple Helix invites the consideration on socio-ecological environment to be included at the onset of the research process, ensuring accountability on the ecological impact of the innovation.

The extension from Triple Helix to Quadruple and Quintuple Helix shows that UTT as a process needs to be increasingly networked (Hayter, 2016). For universities to contribute to socio-economic development, universities must understand their stakeholders and leverage on these networks of stakeholders (Miller et al., 2014). Therefore, relationship building is seen to be a key determinant of UTT mechanisms to lead to societal-based innovation.

The ideas of co-creation and co-producing innovation (Voorberg et al., 2015; Chin et al., 2019) have altered the structure and configuration of UTT. We argue that as the helix concept has been extended to include multiple stakeholders more

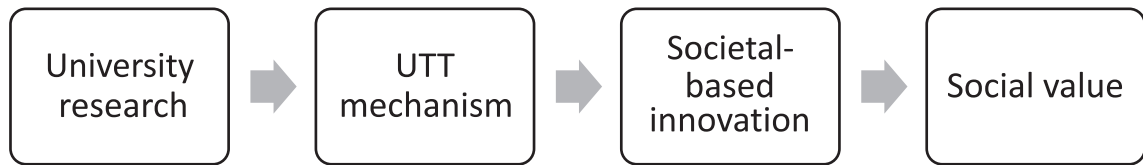


Fig. 5. UTT for social value.

explicitly, the AE process, thus, will also need extension. And so will the performance indicators of UTT mechanisms that will allow universities to demonstrate contributions to multiple bottom lines.

4.6. A new conceptualization of academic entrepreneurship & university technology transfer

Our findings suggest a route through which UTT mechanisms could be reorganized to deliver innovation-based outputs that although may be fundamentally un-patentable but would be more in-line with universities' third mission mandate.

This route requires the development of a more inclusive conceptualization of the AE and UTT concepts. AE's formal conceptualization as highlighted in Fig. 1 is not inclusive – entrepreneurship occurs within university settings in functions and departments beyond the sciences and engineering; it occurs in law, political science, philosophy, languages, mathematics, social sciences and indeed within academic support functions. Therefore, any view on AE must not only include activities that go beyond traditional academic roles and boundaries but also any activity by university staff (academic and non-academic/administrative) that contributes to socio-economic development. Those members of university staff who step beyond their strictly defined roles and university boundaries to contribute to a university's third mission mandate should be duly credited as academic entrepreneurs.

There is support in the literature for the proposed more inclusive view of AE outlined above. To illustrate, Cinar and Benneworth (2020) contend that universities' over-focus on the commercial output of hard sciences research, comes at the cost of ignoring wider entrepreneurial processes that are more prevalent in the social science disciplines. This over-focus also limits the kinds of 'innovation' that generate formal IP to only ground-breaking technology which is exclusive to research intensive or elite universities (Wright et al., 2008, 2009). We find that contemporary research on social entrepreneurship and social innovation questions formal IP's relevance in generating social impact (Fini et al., 2018). There are many pressing problems in society; and the increase in the number of social enterprises highlights failure in public provision (Gofen, 2015; Barbour and Luiz, 2019; Chin et al., 2019). Thus, universities are invited to contribute to these pressing issues by adopting a broader definition of AE, which would ultimately alter existing UTT mechanisms. Hence, Miller et al.'s (2018) term 'entrepreneurial academics', as opposed to academic entrepreneurs is apt as it is more inclusive and allows for the aim of demonstrating wider social impact to be put into practice.

To summarize, we propose the introduction of societal-based innovation as a legitimate UTT mechanism for demonstrating contribution to socio-economic development agendas. This should be done by explicitly recognising the 'social value' of all types of university research not just patentable science and technology based. This conceptualization of AE and UTT is labelled as Model 2 (see Fig. 5).

5. Propositions and future research questions

We have established that formal UTT mechanisms focus on the commercialisation of science and technology innovation with little recognition of other types of innovation that could positively influence society beyond the confines of the university. These 'other' types of innovation are labelled 'societal-based innovations'. In this section, three propositions and accompanying research questions are put forth for further examination and to advance theory in the area of AE and UTT.

First, demonstrating social impact is becoming a key indicator for measuring AE performance and is an important aspect of universities' third mission. This notion has created a gap between universities' present rationale behind UTT activities and their stated mission and expected societal role. Fundamentally, universities are knowledge production and exchange institutions; the dis-connect highlighted above has created a need to re-conceptualise the value ascribed to products of university knowledge activities. Universities need to reassess the alignment between their missions and knowledge creation and dissemination activities for greater coherence to changing expectations by society. Therefore, we propose:

Proposition 1: *Entrepreneurial universities' wider activities to address societal-based innovation will alter UTT's performance indicators.*

RQ1: *How can we design performance indicators for UTT success that can focus on multiple bottom lines?*

RQ2: *How does the national/regional innovation system influence UTT practices in various contexts, specifically in facilitating the broader definition of innovation?*

RQ3: *How can social value be ascribed to all types of university research?*

Second, the non-direct commercial routes of a university's TT are not sufficiently theorised on in the UTT literature. Studies on UTT have often built on existing commercialisation models that lead to a desirable financial bottom line. However, these

studies tend to investigate only a partial or fragmented aspect of the TT process (Good et al., 2018), not capturing its complexity and the requirements for it to fit into a broader social agenda that universities are required to promote. Non-patentable research and other innovations remain largely outside the boundaries of the formal UTT mechanism. The focus on financial bottom lines erodes the notion of multi-dimensional value associated with the broad definition of innovation needed for societal-based innovation. Thus, we propose:

Proposition 2: *University research of all types can result in societal-based innovations that will lead to increased social value.*

RQ4: *How can we design suitable business models for the commercialisation of societal-based innovation?*

RQ5: *What institutional arrangements and organisational configurations are needed at universities for facilitating societal-based innovation?*

RQ6: *How can intermediaries such as TTOs re-position themselves to facilitate TT beyond science and technology research?*

Third, the ongoing development on the helix concept from Triple to Quadruple to Quintuple has validated the need for universities' AE activities to address multiple bottom lines. This means that instead of analysing the effectiveness of current and existing UTT models through the helix theoretical model, attention must now be shifted on how best can UTT contribute to societal challenges by including *multiple stakeholders*. User-stakeholders must not be viewed as mere passive recipients of university innovation, but as co-creators involved actively in the innovation process. Further, the notion of upstream engagement requires bringing multiple actors from the public (non-traditional science actors) and other stakeholders to initiate meaningful dialogue about potential hazards arising from new science and technology. This urgent need is driven by a climate of mistrust from society towards advancements in technology, especially in sensitive technology that has potential for miss-use such as bioengineering, nanotechnology, neuroscience, artificial intelligence, etc. Through upstream engagement, the aim is to ensure accountability of science and technological advancements to society as a whole. Thus, we propose:

Proposition 3: *Involving multiple stakeholders within the Quadruple and Quintuple Helix concept will align the UTT mechanism to societal-based innovation.*

RQ7: *What UTT mechanisms can be deployed to create meaningful engagement with external stakeholders for facilitating responsible societal-based innovation?*

RQ8: *How can relationships and interactions be managed and leveraged upon?*

Based on the above propositions, we invite future researchers to embrace the broader definition of AE to allow emerging models of UTT to better capture societal benefits on top of bottom-line profits. There is an opportunity for exploring how performance indicators may be adjusted in universities in order to better align mission, expectation and expected roles. We invite researchers to use the institutional and mechanisms theory lenses for exploring how goal and mission shifts influence actors within the university, and in turn how these actors change the manner in which AE is perceived. Additionally, we also invite researchers to unpack and map the interaction mechanisms between traditional AE actors and contemporary ones (user-stakeholders). New theory on how these interactions occur and what influences the quality of relationships between multiple stakeholders will extend knowledge in the area.

6. Conclusion

The focus in the paper was to bring to fore an under-researched theme within the AE and UTT discourse, one with important implications for universities' role in society – social development in conjunction with economic development. There are open debates and unanswered questions on universities' new role in society, the value-capture problem in AE and UTT, and helix metaphors.

Our findings suggest that there is wide-ranging prevalence of the Schumpeterian model of innovation at universities that has a narrow focus on commercialisation for profit generation. 'Other' types of innovation, such as social innovation, that emphasise on multiple bottom lines needs pronounced attention. These 'other' types of innovations can contribute to socio-economic development agendas and need more explicit recognition and capturing in impact indicators tied to university research.

Ultimately, this paper highlights that an emphasis on societal-based innovation by universities can positively alter the formal UTT mechanism. We have presented three propositions and accompanying research questions that can inform future research and invite scholars in UTT and AE research to continue this ongoing conversation on inclusive reform needed at universities to address global socio-economic challenges.

Declaration of competing interest

The authors declare no conflicts of interest.

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Appendix 1. Journals included with JCR IF > 2

Area	Journal Name	IF
Entrepreneurship	<i>Entrepreneurship, Theory and Practice</i>	4
	<i>Journal of Business Venturing</i>	4
	<i>Strategic Entrepreneurship Journal</i>	4
	<i>Entrepreneurship and Regional Development</i>	3
	<i>Small Business Economics</i>	3
Innovation	<i>Research Policy</i>	4*
	<i>Journal of Product Innovation Management</i>	4
	<i>R and D Management</i>	3
	<i>Technovation</i>	3
	<i>Creativity and Innovation Management</i>	2
	<i>Industry and Innovation</i>	2
	<i>Innovation: Organization & Management</i>	2
	<i>International Journal of Innovation Management</i>	2
	<i>Journal of Engineering and Technology Management</i>	2
	<i>Journal of High Technology Management Research</i>	2
	<i>Journal of Technology Transfer</i>	2
	<i>Prometheus</i>	2
	<i>Research Technology Management: international journal of research management</i>	2
	<i>Science & Technology Studies</i>	2
	<i>Science, Technology & Human Values</i>	2
	<i>Scientometrics</i>	2
	<i>Social Studies of Science</i>	2
	<i>Structural Change and Economic Dynamics</i>	2
	Higher Education	<i>Academy of Management, Learning and Education</i>
<i>Studies in Higher Education</i>		3
<i>Higher Education</i>		2
<i>Higher Education Policy</i>		2
<i>Higher Education Quarterly</i>		2
<i>Journal of Higher Education</i>		2

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