



# Transferring Scientific Knowledge to Academic Startups: the Moderating Effect of the Dual Identity of Academic Entrepreneurs on Forming Knowledge Depth and Knowledge Breadth

Yuanyuan Chen<sup>1</sup> · Wei Liu<sup>1</sup> · Stavros Sindakis<sup>2</sup>  · Sakshi Aggarwal<sup>3</sup>

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## Abstract

This paper explores the mechanism for knowledge transfer of academic entrepreneurs by using the knowledge spillover theory of entrepreneurship (KSTE) and identity theory. We classified academic entrepreneurs into two distinct hybrid types, “hybrid scientists” and “hybrid entrepreneurs,” based on different identity centralities and conducted an empirical study on the relationship among academic entrepreneurs’ scientific knowledge, the two dimensions of their firms’ knowledge base (knowledge depth and knowledge breadth), and their various hybrid roles. This study involving 176 academic start-ups from National Equities Exchange and Quotations (NEEQ) in China discovered that academic entrepreneurs’ scientific knowledge positively contributes to the emergence of academic start-ups’ knowledge base. The different dual identities moderately affect the relationship between academic entrepreneurs’ scientific knowledge and their firms’ knowledge depth and breadth. The results suggest that academic entrepreneurs who are also “hybrid scientists” can positively promote the development of the firms’ knowledge breadth, and the “hybrid entrepreneurs” deepen the knowledge depth of academic start-ups.

**Keywords** Knowledge transfer · Knowledge breadth · Knowledge depth · Academic entrepreneurs · Dual identity

## Introduction

Based on scientific research, academic start-ups are knowledge-intensive firms. The potential of turning universities’ scientific knowledge into firms’ market-valued knowledge and technology is vital for them (Los & Verspagen, 2007; Sharker et al., 2007). The

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✉ Wei Liu  
liuwei@cqu.edu.cn

Extended author information available on the last page of the article

transformation of scientific knowledge into technological inventions is arduous due to the varying nature of science and technology (Kuo et al., 2019; Sauermann & Stephan, 2010). Scholars argue that scientific knowledge is more exploratory, whereas technological knowledge is more exploitative (Meyer, 2002; Fabrizio, 2009; Al-Mubarak & Busler, 2017). Universities generate scientific knowledge to better understand the world rather than produce immediate applications (Cassiman et al., 2008; McMillan et al., 2000). The companies develop innovative technology to respond to the market demands and consumer needs (Makri et al., 2010). Therefore, the logic of scientific discovery and new technology development clash, resulting in a complex, uncertain, and intricate knowledge transformation process for academic start-ups (Kuo et al., 2019).

According to the knowledge spillover theory of entrepreneurship (hereafter KSTE), academic entrepreneurs are crucial for knowledge transfer, translation, and dispersion between academia and industries (Sapir, 2021). It is argued that academic entrepreneurs establish start-ups to exploit the non-commercial knowledge from universities and research institutions to commercialize it into product applications (Minola et al., 2021; Ghio et al., 2015; Abereu & Grinevich, 2017). They are founders, scientists, and university faculties who provide the primary knowledge source of academic start-ups (Francis et al., 2015; Hambrick & Mason, 1984). Several academic entrepreneurs chose to remain at universities while starting their ventures (Powell & Sandholtz, 2012; Yusof & Jain, 2009). They are defined as hybrids with the duality of a scholar and entrepreneur (Guo et al., 2019b; Walter et al., 2016). Concurrently embedded on both sides, the unique hybrid identity of academic entrepreneurs enables them to straddle different knowledge domains between academia and industries (Fisher & Atkinson-Grosjean, 2002; Sapir, 2021; Sauermann & Roach, 2012). This positively facilitates their knowledge transfer to their ventures (Dokko et al., 2014; Currie et al., 2015; Lam, 2018) and contributes to forming their firms' knowledge base. The mechanism of this formation of the knowledge base of academic start-ups remains unclear.

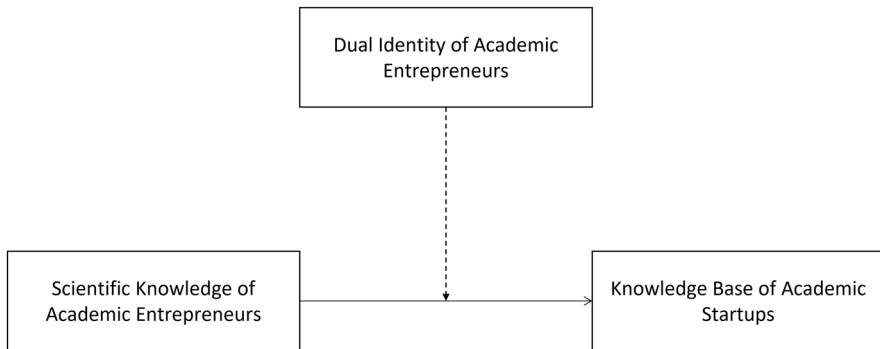
Based on the knowledge-based view, knowledge depth and breadth are the two dimensions of the firms' knowledge base (Judge et al., 2015; Volberda et al., 2010). Knowledge depth is considered more important to firms in the early technology stage. It increases the complexity and rigidity of firms' knowledge structure (Al-Mubarak & Busler, 2017; Mannucci & Yong, 2018) and provides the core competence of firms in a certain technological domain (Prabhu et al., 2005). Meanwhile, knowledge breadth is considered more beneficial for firms in the long run as it directly impacts firms' absorptive ability and innovation (Carlo et al., 2012). Scholars discovered the close relationship between identity work and knowledge boundary work (Gieryn, 1983). Different hybrid identities have different strategies in their knowledge works (Lam, 2018). The academic entrepreneurs have diverse self-concepts for their roles as scholars and entrepreneurs. Thus, the identity centrality of their dual identity differs (Wang et al., 2022). According to the identity theory, identity centrality is the self-concept of the relative importance of one's focal identity (Murnieks et al., 2014). The different identity centralities make the hybrids behave differently during their entrepreneurial activities (Fenters et al., 2017). It leads to a different performance of their knowledge transfer. Therefore, understanding different identity centralities of hybrids in knowledge transfer and forming the knowledge base of academic start-ups are essential.

This study explores the knowledge transfer mechanism of academic entrepreneurs forming the two dimensions of their firms' knowledge base and the impacts of their different dual identities on this mechanism. There are two main contributions of this study to the existing literature. First, we advanced studies of KSTE in the context of academic entrepreneurship (hereafter AE). We emphasized the crucial role of academic entrepreneurs in forming firms' knowledge base, regarding university as the main source of knowledge spillovers through knowledge transfer. We discovered the moderating effects of their dual identity on structuring academic start-ups' knowledge base. Second, this work focused on the study of founders' hybrid identities and knowledge boundary work. The previous studies mainly discussed different identity work of hybrids and their roles in knowledge disruption (Dokko et al., 2014; Currie et al., 2015; Lam, 2018; Lam, 2020). This paper categorized two distinct dual identities of academic entrepreneurs based on identity centrality. We extended the research by exploring the consequence of different hybrids' knowledge boundary work on firms' two knowledge dimensions. The paper is as follows: the “[Theory and Hypotheses](#)” section provides the theory and hypothesis applied in this work. “[Research Methodology](#)” describes the sample collection and research method used. “[Analysis of Findings](#)” contains the data analysis and empirical results. The “[Discussion](#)” and “[Conclusion](#)” sections address the discussion and conclusion of this study.

## Theory and Hypotheses

Based on KSTE, knowledge spillovers and entrepreneurial activities are positively related. The endogenous entrepreneurial opportunities result from knowledge spillovers identified and exploited by entrepreneurs (Acs et al., 2004, 2013). They create academic start-ups for academic entrepreneurs, responding to opportunities arising from non-commercialized knowledge by universities or research institutions (Ghio et al., 2015). To achieve this, they must transfer and turn their scientific knowledge into valuable knowledge for their firm (Rorwana & Tengeh, 2015). Thus, forming academic start-ups' knowledge base results from the knowledge transfer of academic entrepreneurs. Therefore, we believe academic entrepreneurs' scientific knowledge and their firms' knowledge base are closely related.

Scholars also identified academic entrepreneurs employed in universities and their firms as hybrids with a dual identity of a scholar and entrepreneur (Guo et al., 2019b; Walter et al., 2016). Hybrids have advantages in disrupting boundaries and transferring knowledge across different domains regarding identity work (Currie et al., 2015; Dokko et al., 2014). Therefore, we assume academic entrepreneurs' dual identity moderates the formation of their firms' knowledge base through the above knowledge transfer process and helps develop the following research model (Fig. 1).

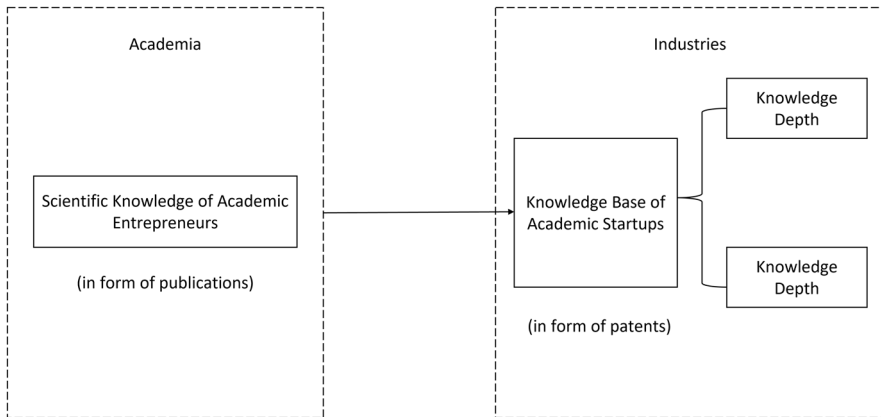


**Fig. 1** Framework of the research model. Note: Dashed line means moderating effect

### Knowledge Transfer Process of Academic Entrepreneurs and Knowledge Base of Academic Start-ups

It includes leveraging knowledge spillovers from universities, as academic entrepreneurs are keen to move scientific knowledge from their research life to their start-ups (Minola et al., 2021). Academic start-ups can benefit from the knowledge originating from universities and research labs (Colombelli et al., 2016). The knowledge in academia and industries is fundamentally different. In academia, abstract/analytical knowledge is privileged and is expressed in texts (Bhardwaj, 2019; Niedderer & Reilly, 2010). Academic research is based on science and basic research; the sharing and production of research findings and inventions are based on non-financial incentives (Sauermann & Stephan, 2010; Stephan, 1996). Industry knowledge is highly experiential and expressed in non-textual forms (Ewenstein & Whyte, 2007; Laperche & Liu, 2013). Industrial science is crucial, and the research environment is more structured and closed (Sauermann & Stephan, 2010; Partha & David, 1994). The research mission in academia is to conduct basic research and produce efficient publications because of the distinctiveness of the two domains. However, the industry's research mission discourages publishing and depends on patenting and secrecy (Sauermann & Stephan, 2010). The successful transformation of universities' scientific knowledge to firms' market-valued knowledge depends on combining the academic entrepreneurs' scientific knowledge with managerial skills. It helps explore and exploit new business opportunities through knowledge transfer (Baniyadi et al., 2021; Ding, 2011). Knowledge transfer of academic entrepreneurs is their transformation of scientific knowledge in publications into firms' patents. The emergence of firms' knowledge base results from the knowledge transfer process (Fig. 2).

Regarding the knowledge-based view, the knowledge base of academic start-ups is structured by two distinct dimensions—knowledge depth and knowledge breadth (Judge et al., 2015; Volberda et al., 2010). Knowledge depth is the degree of specialization of knowledge composition (Kassicieh, 2010; Suman & Maria, 2014). The sophistication of a technology domain leads to a “deeper” knowledge base (Wang & Tunzelmann, 2000;



**Fig. 2** Knowledge transfer process of academic entrepreneurs and dimensions of their firms' knowledge base

Jonsson et al., 2015). Knowledge breadth is the scope of knowledge explored by companies with a degree of knowledge diversification (Suman & Maria, 2014). Academic entrepreneurs are founder and technology leaders who produce the primary source of their firms' knowledge (Francis et al., 2015; Hambrick & Mason, 1984). Academic entrepreneurs are firmly imprinted by their universities because of their long-time work experience in the laboratory (Bazan et al., 2020; Knockaert et al., 2011; Marozau et al., 2021). Instead of turning their knowledge into application, they accumulated scientific knowledge to discover more innovative possibilities (Miller et al., 2018; Suman & Maria, 2014) that enhance their start-ups' wider range of knowledge scope. Other scholars also argued that academic entrepreneurs have advantages in exploring and searching for knowledge in the technological domain (de Castro Peixoto et al., 2021; Engidaw, 2021; Hahn et al., 2019). This is because academic entrepreneurs are experts in their research fields. They are sophisticated in advanced technological knowledge and have better foresight in the technological area (Feola et al., 2021; Guo et al., 2021). They can benefit their firms by accumulating advanced technological knowledge in that domain. We believe academic entrepreneurs contribute to their firms' knowledge depth and knowledge breadth and make the following hypotheses:

H1a: Academic entrepreneurs' scientific knowledge positively impacts the knowledge depth of their firms.

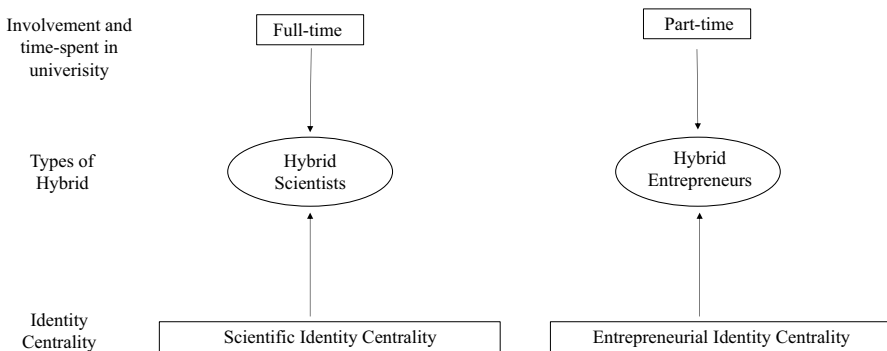
H1b: Academic entrepreneurs' scientific knowledge positively impacts the knowledge breadth of their firms.

### **Moderating Effects of Academic Entrepreneurs' Different Dual Identities**

Academic entrepreneurs remaining at their universities and founding start-ups (Powell & Sandholtz, 2012) are hybrids operating in the "overlapping space" between academia and industries (Lam, 2018). Academic entrepreneurs are dually embedded inside due to their hybrid identity. This benefits them in facilitating and transforming divergent knowledge from separated knowledge domains (Dokko et al., 2014; Mishra & Tripathi, 2021; Pancholi et al., 2014). We believe the dual identity of academic entrepreneurs moderates their knowledge transfer process. Hybrid identity work includes mixing and crossing two

different identities (Purchase et al., 2018). Academic entrepreneurship is not a dichotomous identity transition from scholar to entrepreneur but an exhibit of dual identities by the academic entrepreneur (Amofah & Saladrignes, 2022; Brem & Wolfram, 2014; Shi et al., 2021). The conception of academic entrepreneurs on the importance of their two identities differs (Rypestøl, 2017; Wang et al., 2022). Identity centrality is the self-concept on the relative importance of one's focal identity and is related to an individual's behavioral decisions (Murnieks et al., 2014; Ulhøi, 2021). In the context of AE, identity centrality properly explains the relationship between the entrepreneurial/scientific domain of academic entrepreneurs' hybrid role (Arafah, 2016; Carayannis et al., 2015; Wang et al., 2022) and their behaviors (Fenters et al., 2017). Hybrid with different identity centralities has various ways in which knowledge boundary works (Fenters et al., 2017; Wang et al., 2022). The different degrees of involvement for academic entrepreneurs and their time spent in university while working in their start-ups reflect their self-concept on the importance of their scholar and entrepreneur role. Thus, we classified two distinct types of hybrid roles of academic entrepreneurs, "hybrid scientists" and "hybrid entrepreneurs." Fig. 3 illustrates the theoretical framework of the hybrid category.

The "hybrid scientists" are academic entrepreneurs holding full-time university positions while working on their start-ups. They are hybrids with a scientific identity centrality and act like scientists (Wang et al., 2022). "Hybrid scientists" spend the majority of their time on teaching and research activities to remain full-time professors and scientists and are firmly imprinted by the academic environment (Bazan et al., 2020; Knockaert et al., 2011). These entrepreneurial activities help them explore and exploit opportunities to further their research (Miller et al., 2018). Based on KSTE, for knowledge spillover of founders' scientific expertise from their academic life, "hybrid scientists" cannot transfer their technology to specific applications but explore knowledge in a broader range (Suman & Maria, 2014; Wright et al., 2007). They have a scientific perception and prefer to generate knowledge for their scientific part. It also includes commercializing more general-purpose technology with broader possibilities for their start-ups and other industrial players (Colombo et al., 2010; Fini et al., 2018). They realize that specific technology commercialization is inferior (Visintin & Pittino, 2014) and prefer pursuing knowledge



**Fig. 3** Theoretical framework of categories of hybrids

with more possibilities, which results in a broader scope of their firms’ knowledge. “Hybrid entrepreneurs” are academic entrepreneurs who are fully engaged in their start-ups and take part-time university positions. They are hybrids with entrepreneurial identity centrality and aim to gain financial returns through technology commercialization (Etzkowitz et al., 2000; Wathanakom et al., 2020). “Hybrid entrepreneurs” take managerial positions in their start-ups and have proactive involvement in the business decisions of their firms (Dahl & Reichstein, 2007). They have a greater “taste for commercialization” (Sauermann & Stephan, 2010) and will probably innovate to serve specific customer needs (Allen, 2022; Chatterji, 2009). They intend to transfer and turn the knowledge to support specific products or services. They prefer to realize specific commercial targets by focusing on a narrow technology domain within their firms instead of pursuing technology development through constant R&D (Minola et al., 2021; Uhm et al., 2018). This brings about the firms’ knowledge in a particular field. Based on the above, we propose the following hypotheses:

H2a: The hybrid role of “hybrid scientists” positively moderates the relationship between academic entrepreneurs’ scientific knowledge and the knowledge breadth of their firms.

H2b: The hybrid role of “hybrid entrepreneurs” positively moderates the relationship between academic entrepreneurs’ scientific knowledge and the knowledge depth of their firms.

Figure 4 illustrates the conceptual model of this study. It summarizes the hypothesis, mainly describing the different dual identities of the academic entrepreneurs, i.e., hybrid scientists and hybrid entrepreneurs. Based on the knowledge spillover theory of entrepreneurship, for knowledge spillover of founders’ scientific expertise from their academic life, “hybrid scientists” cannot transfer their technology to specific applications but explore knowledge in a broader range. Similarly, academic entrepreneurs who are fully immersed in their start-ups while working part-time at

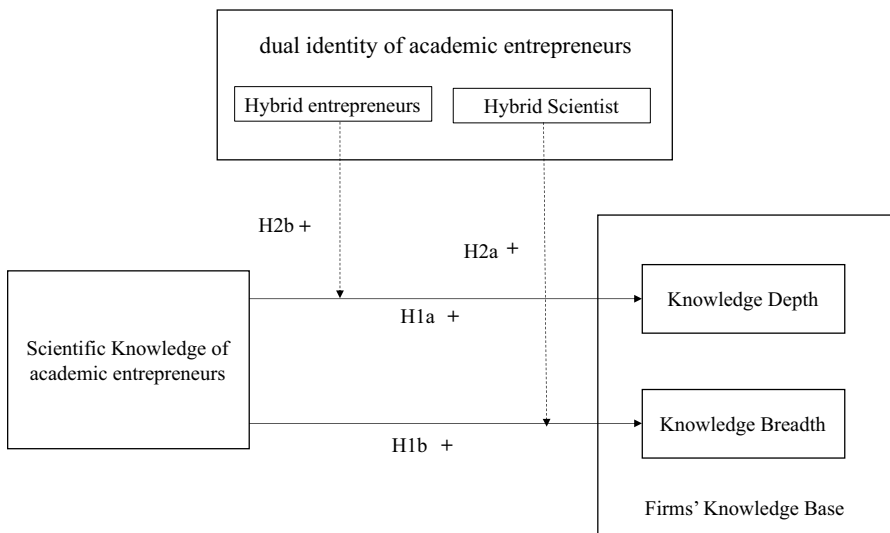


Fig. 4 Conceptual model

universities are known as “hybrid entrepreneurs.” They are hybrids with a robust entrepreneurial identity who want to make money through technology commercialization. Based on this, our research hypothesized (H2a and H2b) that the hybrid role as “hybrid scientists” positively moderates the relationship between academic entrepreneurs’ scientific knowledge and the knowledge breadth of their firms. Also, the hybrid role of “hybrid entrepreneurs” positively moderates the relationship between academic entrepreneurs’ scientific knowledge and the knowledge depth of their firms. Therefore, the successful transformation of universities’ scientific knowledge into firms’ market-valued knowledge necessitates combining academic entrepreneurs’ scientific expertise with managerial abilities. In this CM, we investigated the impact of a firm’s knowledge depth and knowledge breadth on academic entrepreneurs’ scientific expertise. As a result, we believe that academic entrepreneurs contribute to the knowledge depth and breadth of their enterprises, and we hypothesized that entrepreneurs’ scientific expertise has a positive impact on their firms’ knowledge depth and breadth.

## Research Methodology

### Empirical Setting and Data Collection

This paper collects data from academic start-ups listed on National Equities Exchange and Quotations (hereafter NEEQ) in China and conducts an empirical examination to test the theoretical hypothesis. We have several reasons to choose data from NEEQ. First, China is the world’s second-largest economy. Recently, university faculties and scientists are increasingly engaging in technology commercialization, and academic start-ups are growing dramatically. This provides us with a proper setting with sufficient data for this study. Second, many academic start-ups are small- and medium-sized enterprises (SMEs) (Agarwala & Shah, 2014), and NEEQ is the “over-the-counter” (OTC) after Shanghai Stock Exchange and Shenzhen Stock Exchange that fits the research setting.

The research defines academic entrepreneurs as scientist shareholders having worked in a university lab or research institution where the firms’ technology originated (Hmielesk & Powell, 2018; Svare, 2016). They are vital members of the board, top management team, or technology team. We exclude academic entrepreneurs who are unemployed by universities and start-ups as we think they lack dual identities to observe the impacts of different hybrid roles. We eliminate firms with academic entrepreneurs with inadequate information in publications and personal resumes by searching and reading prospectuses, company website, university website, and databases of CNKI. We also removed start-ups with insufficient data and finally selected 176 academic start-ups from 6898 companies in NEEQ (Table 1 shows the description of samples).



**Table 1** Description of samples

Categories		Frequency
Industries	Manufacturing	43
	Chemical	10
	Oil, metals, and mining	14
	Pharmaceutical	48
	TMT	55
	Others	6
Firm age	Under 5	12
	5–10 years	58
	11–20 years	83
	21 and over	23
Positions of academic entrepreneurs in firms	Full-time	74
	Part-time	102

## Measures

### Academic Entrepreneur's Scientific Knowledge: Publications

Academic entrepreneurs are scientists and university faculties who shift from working in laboratories to being entrepreneurs (Francis et al., 2015). They accumulate scientific and technical knowledge from their scientific research and academic training in universities. The acknowledged publications of these scholars are highly valued in the academic world (Sauermaun & Stephan, 2010). It indicates academic achievement and sophistication in a specific research domain. Thus, we used the number of publications of academic entrepreneurs to measure their stock of scientific knowledge.

### Knowledge Base of Academic Start-ups: Knowledge Depth and Knowledge Breadth

According to the knowledge-based view, knowledge depth and knowledge breadth are two dimensions of firms' knowledge base (Judge et al., 2015; Volberda et al., 2010). In the business world, companies emphasize producing patents with financial returns. Thus, the research model adopts the method of Ozman (2007), Katilar and Ahuja (2002), and Suman and Maria (2014) to calculate the knowledge depth and knowledge breadth by patents. We quantized patents by calculating the International Patent Classification (IPC) code. Before proceeding with knowledge depth and knowledge breadth, we must mention the structure of the IPC system. In the IPC system, eight sections are revealed by the code's first character (expressed by the letters A–H). The first three characters, divided into subclasses, display the classes. The groups are revealed by the first six characters, for example, G06C7/02. Here, G is the section for physics. G06 implies the class (computing, calculating, and counting), and G06C represents the subclass (digital computers, where computation is

conducted mechanically). G06C7 is the group level, and G06C7/02 is the subgroup level that corresponds to keyboards.

We employed the measure of knowledge depth and knowledge breadth based on the number of IPC codes of patents from an academic start-up. We precisely measured the knowledge depth by the usage of technology (classification of IPC code) in patents. The formula for measuring knowledge depth is as follows:

$$\text{Depth} = \left(\frac{1}{n\text{Tech}}\right)^2 \frac{\text{Repeated}_{\text{IPC}}}{\text{Total}_{\text{IPC}}}$$

$\text{Repeated}_{\text{IPC}}$  refers to the number of IPC codes (group level) that have appeared several times in a company's patents.  $\text{Total}_{\text{IPC}}$  refers to the total number of patents produced by the company.  $n\text{Tech}$  refers to the number of technology domains (group level) included by the total patents. The scope of new technologies measures the knowledge breadth (classification of IPC codes) included in firms' patent. The formula for calculating the knowledge breadth is as follows:

$$\text{Breadth} = \left(\frac{1}{n\text{Tech}}\right)^2 \frac{\text{Unsed}_{\text{IPC}}}{\text{Total}_{\text{IPC}}}$$

$\text{Unsed}_{\text{IPC}}$  refers to the numbers of IPC codes that have appeared once by the company.  $\text{Total}_{\text{IPC}}$  refers to the total number of patents produced by the company.  $n\text{Tech}$  refers to the number of technology domains (group level) included by the total patents.

### Hybrid Identities of Academic Entrepreneurs

We used dummy variables to represent the two distinct hybrid identities of academic entrepreneurs. We categorized academic entrepreneurs as “hybrid scientists” and “hybrid entrepreneurs” based on their duration at their universities after founding academic start-ups. The majority of academic entrepreneurs choose to remain at their full-time positions in their universities (Powell & Sandholtz, 2012). We call them “hybrid scientists” with a scientific identity centrality, and they behave in a “scholarly” way. We assigned 1 to the academic entrepreneurs of this group. “Hybrid entrepreneurs” are also academic founders with an entrepreneurial identity centrality. They actively engage in business and only take full-time jobs in universities. In this research, they serve as “entrepreneurs” and are assigned to 0.

### Control Variables

Although academic entrepreneurs are crucial for the knowledge formation of start-ups, other factors may influence this mechanism. We consider several control variables for factors that may affect the hypotheses. Based on the study of Suman and Maria (2014), we take firm size, firm age, and R&D intensity as the control variables as they cause an increase in patents and innovative capacity. Considering the financial effect on firms' innovative activities, we also control the debt ratio in this research. Table 2 proposes a specific method of calculating these control variables.

**Table 2** Control variables and measurements

Control variable	Measurement method
Firm size (FS)	The enterprise size is the natural logarithm of the total asset
Firm age (FA)	The age of the enterprise is based on the year of the company’s establishment
R&D intensity (R&D)	$R \ \& \ D \ intensity = \frac{R \ \& \ D \ expenditure}{Prime \ operating \ revenue}$
Debt ratio (DR)	$Deb \ ratio = \frac{Total \ debts}{Total \ assets}$

### Analysis of Findings

Table 3 shows the mean, standard deviation, minimal number, and the maximal number of each variable. The sample includes 176 academic start-ups in NEEQ with 13,376 valid patents in total. We take the logarithm of the number of publications and firm age, considering the differences in magnitude among different variables. Based on the results, the mean of knowledge depth is 0.464, while the mean of knowledge breadth is 0.488. It indicates that most academic start-ups have a wider scope of knowledge in different domains, resulting in a broader knowledge base. The mean of dual identity is 0.580, which suggests that the majority of academic entrepreneurs choose to retain full-time positions at their universities while working in their start-ups. This finding remains consistent with the discovery in the previous work of Powell and Sandholtz (2012).

Table 4 shows the correlations between knowledge depth and knowledge breadth. We also calculate the variance inflation factor (VIF) to exclude the effect of multicollinearity on the regression results. According to the study’s results, the VIFs range from 2.710 to 1.027. The acceptable value of 5 shows no multicollinearity effects in this research. Table 3 also reveals a positive correlation between knowledge depth

**Table 3** Descriptive statistics

Variables	Numbers	Min	Max	Mean	Standard deviations
KD	176	0.084	1	0.464	0.260
KB	176	0.046*	0.922**	0.488	0.194
Pub	176	1.540	3.980	3.273	0.335
DI	176	0	1	0.580	0.495
FA	176	1.099	3.178	2.527	0.496
DR	176	0.049*	1.150	0.603	0.344
FS	176	3.823	9.152	6.520	1.537
R&D	176	0.001***	3.091	1.544	0.840

*KD* knowledge depth, *KB* knowledge breadth, *DI* dual identity, *FA* firm age, *DR* debt ratio, *FS* firm size, *R&D* intensity, *N* = 176

\**P* < 0.05; \*\**P* < 0.01; \*\*\**P* < 0.005

**Table 4** Correlations between knowledge depth and knowledge breadth

Variables	KD	KB	DI	Pub	FA	DR	FS	R&D
KD	1							
KB	0.101	1						
DI	0.033*	-0.019	1					
Pub	0.716***	0.527***	0.054	1				
FA	0.265***	0.232**	-0.046	0.261***	1			
DR	-0.042	0.083	0.063	0.015	0.054+	1		
FS	0.122	0.205**	0.093	0.202**	0.008	0.117	1	
R&D	0.094	0.109	-0.064	0.116	-0.018	0.010	-0.000	1

*KD* knowledge depth, *KB* knowledge breadth, *DI* dual identity, *FA* firm age, *DR* debt ratio, *FS* firm size, *R&D* intensity, *N* = 176

\* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.005$ ; + $P < 0.1$

and academic entrepreneurs' number of publications, as the correlation coefficient is 0.716 ( $P < 0.005$ ). Knowledge breadth also has a positive correlation with academic entrepreneurs' number of publications, and the correlation coefficient is 0.527 ( $P < 0.005$ ).

We performed hierarchical OLS regression using Matlab 2018 version to test the hypotheses. Tables 5 and 6 represent the results of the knowledge depth (KD) and knowledge breadth (KB) as dependent variables. For each table, we present three models.

In Model 1 and Model 4, we include the control variables, which are firm age (FA), debt ratio (DB), firm size (FS), and R&D intensity (R&D). In Model 2 and Model 5, we introduced the publications of academic entrepreneurs (Pub) to test H1a and H1b. In Model 3 and Model 6, we introduced the dual identity of academic

**Table 5** Regression results for knowledge depth

Variables	Model 1	Model 2	Model 3
FA	0.141***	0.045	0.049 <sup>+</sup>
DR	-0.055	-0.042	-0.051
FS	0.022 <sup>+</sup>	-0.002	-0.001
R&D	0.031	0.005	0.000
Pub		0.540***	0.690***
DI			0.357*
Pub*DI			-0.502*
$R^2$	0.010	0.522	0.535
Adjusted $R^2$	0.078	0.508	0.516
<i>F</i> value	4.711**	37.148***	27.659***

*KD* knowledge depth, *KB* knowledge breadth, *DI* dual identity, *FA* firm age, *DR* debt ratio, *FS* firm size, *R&D* intensity, *N* = 176

\* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.005$ ; + $P < 0.1$

**Table 6** Regression results for knowledge breadth

Variables	Model 4	Model 5	Model 6
FA	0.090**	0.042	0.038
DR	0.026	0.032	0.041
FS	0.025**	0.013	0.012
R&D	0.026	0.013	0.016
Pub		0.273***	0.150*
DI			−0.314*
Pub*DI			0.418*
$R^2$	0.110	0.305	0.324
Adjusted $R^2$	0.089	0.284	0.295
$F$ value	5.280***	14.892***	11.483***

*KB* knowledge breadth, *DI* dual identity, *FA* firm age, *DR* debt ratio, *FS* firm size, *R&D* intensity,  $N=176$

\* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.005$

entrepreneurs (*DI*) to examine the moderating effect of dual identity on publications and knowledge dimensions (knowledge depth and knowledge breadth), thus testing H2a and H2b.

Tables 5 and 6 show that when we introduced the publications in Model 2 and Model 5, the adjusted  $R^2$  significantly increased for all dependent variables (Table 5 from 0.078 to 0.508; Table 6 from 0.089 to 0.284). This suggests that the explanatory power of Model 2 and Model 5 improves by adding the variable of publications. The results show that the coefficient of publications is positive and significant ( $c=0.540$  in Table 5,  $c=0.273$  in Table 6,  $P < 0.005$ ). It confirms that publications of academic entrepreneurs positively influence the emergence of their firms' knowledge depth and breadth. This supports H1a and H1b. Based on this understanding, we conclude that the scientific knowledge of academic entrepreneurs, as discussed in the literature, is positively related to academic start-ups' knowledge base. These findings confirm the arguments in previous literature (Francis et al., 2015; Minola et al., 2021; Abereu & Grinevich, 2017) that academic entrepreneurs contribute to the primary source of academic start-ups' knowledge base. The findings suggest that academic entrepreneurs' scientific knowledge positively relates to the emergence of knowledge depth and knowledge breadth. This may be because academic entrepreneurs are experts in their research field; they are specialized in accumulating advanced knowledge in a certain technological domain (Hahn et al., 2019), thus helping their firms' knowledge depth. In addition, academic entrepreneurs are firmly imprinted by academia; they prefer exploring and exploiting knowledge with a broader knowledge scope to discover more innovative opportunities and broaden their firms' knowledge breadth (Miller et al., 2018; Suman & Maria, 2014).

The following analysis of Models 3 and 6 tests the moderating effect of academic entrepreneurs' dual identity on the relationship between publication and firms' knowledge dimensions. We see that the adjusted  $R^2$  increases in both tables show the strong explanatory power of Tables 5 and 6. Table 5 shows that the interactive

variable (Pub\*DI) is negative and significant ( $c = -0.502$ ,  $P < 0.01$ ). This result demonstrates that academic entrepreneurs with entrepreneurial identity centrality will probably transfer and form deeper knowledge of their start-ups. Thus, the role of “hybrid entrepreneurs” positively moderates the relationship between publications and knowledge depth, thus supporting H2a. Table 6 shows that the interactive variable (Pub\*DI) is positive and significant ( $c = 0.418$ ,  $P < 0.01$ ), which means academic entrepreneurs with scientific identity centrality will probably explore and transfer knowledge breadth. The role of “hybrid scientists” positively moderates the relationship between publications and knowledge breadth, supporting H2b. The findings illustrate that academic entrepreneurs’ dual identity has significant effects on shaping their firms’ knowledge dimensions. Because of their different identity centralities, academic entrepreneurs have various preferences on exploiting knowledge depth and knowledge breadth during their knowledge transfer to their start-ups, resulting in different structures of their firms’ knowledge base.

## Discussion

In this paper, the discussion mainly revolves around the knowledge base of academic start-ups as well as the dual identity of academic entrepreneurs and their knowledge transfer process. The different degrees of involvement for academic entrepreneurs and their time spent in university while working in their start-ups reflect their self-concept on the importance of their scholar and entrepreneur role. Thus, we classified two distinct types of hybrid roles of academic entrepreneurs, “hybrid scientists” and “hybrid entrepreneurs.” Combining academic entrepreneurs’ scientific expertise with managerial skills is necessary for the successful transformation of universities’ scientific knowledge into enterprises’ market-valued knowledge. Knowledge transmission aids in the exploration and utilization of new business prospects. We specifically investigated the impact of knowledge depth of firms on the scientific knowledge of academic entrepreneurs in this report. As a result, academic entrepreneurs are experts in their research fields, and they are sophisticated in advanced technological knowledge and have better foresight in the technological field. To summarize, we believe that academic entrepreneurs contribute to their firms’ knowledge depth and knowledge breadth; thus, we hypothesized that entrepreneurs’ scientific knowledge positively impacts the knowledge depth/breadth of their firms.

It is critical to consider knowledge spillovers created by external sources when developing national policies to support entrepreneurial activity. Policymakers are continually faced with a series of options concerning new ways to encourage innovation and entrepreneurship. Given the significant link between long-term economic development and entrepreneurship, various factors influence how fiscal and other forms of support are provided. In light of our findings, there are several important policy considerations to consider. Based on KSTE, for knowledge spillover of founders’ scientific expertise from their academic life, “hybrid scientists” cannot transfer their technology to specific applications but explore knowledge in a broader range. Additionally, academic entrepreneurs who are fully immersed in their start-ups while working part-time at universities are known as “hybrid entrepreneurs.” They

are hybrids with a robust entrepreneurial identity who want to make money through technology commercialization. Based on this, it is hypothesized in our research that the hybrid role as “hybrid scientists” positively moderates the relationship between academic entrepreneurs’ scientific knowledge and the knowledge breadth of their firms. Also, the hybrid role of “hybrid entrepreneurs” positively moderates the relationship between academic entrepreneurs’ scientific knowledge and the knowledge depth of their firms.

Therefore, technical change leads to innovation improvements, which necessitates internal knowledge investment and the discovery of new ideas and information from other sources, which can be made public or private. New information, on the other hand, is the result of other companies’ and universities’ research and development efforts, which can range from basic research (such as the discovery of new scientific laws) to the development of innovation activities and increased productivity (such as the incorporation of new ideas into products or innovative techniques). Because the incentives of basic research at universities and federal laboratories cannot be fully realized by those who pursue it, it is now widely accepted that start-ups will profit more if the government grants events and collaboration projects and can either maintain them directly or contract them to research universities or institutions that have this relevant data and necessitate start-up skills and market knowledge to monetize it.

## Conclusion

Transforming scientific knowledge into firms’ market–value knowledge is challenging. Academic entrepreneurs are crucial in this knowledge transformation to be hybrid founders (Guo et al., 2019a, b). Concurrently embedded in two domains, the unique dual identity of academic entrepreneurs benefits knowledge transfer across academia and industry (Lam, 2018, 2020). This study explores the various impacts of academic entrepreneurs’ dual identities on their firms’ knowledge base. Based on their different identity centralities, we classify academic entrepreneurs into two distinct types of hybrids, “hybrid scientists” and “hybrid entrepreneurs.” We empirically examine their effects on the formation of knowledge depth and knowledge breadth of academic start-ups through knowledge transfer. The results show the moderating effects of academic founders’ dual identities on the relationship between their scientific knowledge and firms’ two knowledge dimensions. The findings suggest academic entrepreneurs with different identity centrality can lead to various structures of their firms’ knowledge base. The “hybrid scientists” contribute more regarding the knowledge breadth of their firms. Similar to the findings of Wang et al. (2022) and Agarwala and Shah (2014), this study finds that “hybrid scientists” have a scientific identity centrality and treat their start-ups to form their technology (Agarwala & Shah, 2014). They prefer exploring knowledge with more possibilities (Minola et al., 2021) and transferring a broader knowledge scope to their firms (Minola et al., 2021). The results reveal that “hybrid entrepreneurs” with an entrepreneurial identity centrality transfer and form knowledge depth of their start-ups more effectively. This is because they are eager to pursue financial returns

through technology commercialization (Sauer mann & Roach, 2012). They intend to transform their knowledge into specific applications, thus leading to a deeper knowledge base for their firms.

### Theoretical Implications

This research contributes to the literature in several ways by linking KSTE and identity work in the context of AE. Firstly, prior studies of KSTE at the individual level discuss the relationship between academics' entrepreneurial intention and knowledge filters on the knowledge transfer process (Guerrero & Urbano, 2014). Insight on the direct impact of academic founders' knowledge transfer behavior on their firms is rare. This paper fulfills this research gap by exploring the influence of knowledge transfer of academic entrepreneurs on forming their firms' knowledge structures. Secondly, the research highlights the academic entrepreneurs' hybridity. Prior studies on the hybrid identity of academic founders focused on discussing the resolution of their conflict roles and their impact on entrepreneurial performances (Guo et al., 2019b; Riad Shams & Belyaeva, 2019; Shi et al., 2021). We extended the research on identity work and knowledge boundary work by focusing on exploring the impacts of academic entrepreneurs' dual identity on firms' knowledge base and emphasized AE as an essential mechanism of knowledge transfer from university to industry (Mathisen & Rasmussen, 2019; Meng et al., 2019). Based on different identity centralities, this research distinguished two hybrid roles of academic entrepreneurs and identified their different behaviors. We found the moderating role of their dual identity in shaping firms' knowledge structure through knowledge transfer.

### Managerial Implications

The paper also provides several practical implications for academic start-ups. The knowledge base provides the foundation of firms' innovation for knowledge-intensive firms (Choudhury & Haas, 2018). Heterogeneous knowledge bases would lead to different performances of companies (Grant, 1996). Academic start-ups rely highly on scientific research from universities; most are in the early stages of technology. Thus, they need a long time to incubate and successfully commercialize practical applications (Agarwal & Ohyama, 2010). Knowledge depth is critical in firms' early technology stage because it increases the complexity and rigidity of knowledge structure (Mannucci & Yong, 2018). Concentrating on one technological domain can help firms gain competitive advantages in their product field and gain core competence in innovation (Farinha et al., 2016; Prabhu et al., 2005). Thus, "hybrid entrepreneurs" benefit academic start-ups more in their early and growth stages. Academic entrepreneurs need to invest more time and engage actively in their firms, and their main task is to focus on accelerating technology transformation in a specific application field. Knowledge breadth is more important in the long run as it directly impacts the absorptive ability of companies and innovation (Carlo et al., 2012; Dell'Anno & Del Giudice, 2015). When the business grows, academic entrepreneurs must gradually reduce their devotion to companies and shift to a more "scholarly" role. They should focus on knowledge exploration and exploitation through R&D and help their firms gain a broader knowledge scope.



## Limitations and Ideas for Future Research

The limitations of this study provide ideas for future research. First, acknowledging the importance of academic start-ups' knowledge base, this work explores academic entrepreneurs in forming their firms' knowledge base. It is also crucial for these firms to utilize this knowledge to create profitable innovation. Thus, future work could add insight to this question. Given the significant variations in KSTE between start-ups and incumbents, alternative forms of knowledge collaboration with external partners, such as cooperation designed for knowledge producer and knowledge recipient, should be studied, including unpredictability. Further research will combine the open innovation and knowledge transfer literature to describe the breadth and depth of knowledge spillover and the number of knowledge partners and knowledge bases that might be leveraged by entrepreneurs to build fresh-to-market products. Second, this work mainly examines the individual impacts of firms' knowledge formation. Scholars specified that different industries might have varying knowledge orientations in innovation. The science and technology industries have different demands on knowledge features (Davids & Frenken, 2018) that may consequently influence the knowledge structure of firms (Moorthy & Polley, 2010). Therefore, future studies could consider the effects of different industries on developing the firm's knowledge dimensions.

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## Declarations

**Conflict of Interest** The authors declare no competing interests.

## References

- Abreu, M., & Grinevich, V. (2017). Gender patterns in academic entrepreneurship. *The Journal of Technology Transfer*, 42(4), 763–794.
- Acs, Z. J., Audretsch, D. B., Braunerhjelm, P., & Carlsson, B. (2004). The missing link: The knowledge filter and entrepreneurship in endogenous growth. Available at SSRN 667944.
- Acs, Z. J., Braunerhjelm, P., Audretsch, D. B., & Carlsson, B. (2013). The knowledge spillover theory of entrepreneurship. *Small Business Economics*, 32(1), 15–30.
- Agarwal, R., & Ohyama, A. (2010). Industry or academia, basic or applied? Career choices and earnings trajectories of scientists. *Management Science*, 59(4), 950–970.
- Agarwal, R., & Shah, S. K. (2014). Knowledge sources of entrepreneurship: Firm formation by academic, user and employee innovators. *Research Policy*, 43(7), 1109–1133.
- Allen, G. J. (2022). Conceptualize™: A new contribution to generate real-needs-focussed, user-centred, lean business models. *Journal of Innovation and Entrepreneurship*, 11(1), 1–33.
- Al-Mubarak, H. M., & Busler, M. (2017). Challenges and opportunities of innovation and incubators as a tool for knowledge-based economy. *Journal of Innovation and Entrepreneurship*, 6(1), 1–18.
- Amofah, K., & Saladríguez, R. (2022). Impact of attitude towards entrepreneurship education and role models on entrepreneurial intention. *Journal of Innovation and Entrepreneurship*, 11(1), 1–30.

- Arafah, L. (2016). An entrepreneurial key competencies' model. *Journal of Innovation and Entrepreneurship*, 5(1), 1–26.
- Baniasadi, N., Samari, D., Hosseini, S. J. F., & Najafabadi, M. O. (2021). Strategic study of total innovation management and its relationship with marketing capabilities in palm conversion and complementary industries. *Journal of Innovation and Entrepreneurship*, 10(1), 1–14.
- Bazan, C., Gaultois, H., Shaikh, A., Gillespie, K., Frederick, S., Amjad, A., & Belal, N. (2020). A systematic literature review of the influence of the university's environment and support system on the precursors of social entrepreneurial intention of students. *Journal of Innovation and Entrepreneurship*, 9(1), 1–28.
- Bhardwaj, B. (2019). Role of knowledge management in enhancing the entrepreneurial ecosystems through corporate entrepreneurship and strategic intent in high-tech firms. *Journal of the Knowledge Economy*, 10(4), 1831–1859.
- Brem, A., & Wolfram, P. (2014). Research and development from the bottom up-introduction of terminologies for new product development in emerging markets. *Journal of Innovation and Entrepreneurship*, 3(1), 1–22.
- Carayannis, E. G., Dubina, I. N., & Ilinova, A. A. (2015). Licensing in the context of entrepreneurial universality activity: An empirical evidence and a theoretical model. *Journal of the Knowledge Economy*, 6(1), 1–12.
- Carlo, J. L., Lyytinen, K., & Rose, G. M. (2012). A knowledge-based model of radical innovation in small software firms. *MIS Quarterly*, 865–895.
- Cassiman, B., Veugelers, R., & Zuniga, P. (2008). In search of performance effects of (in) direct industry science links. *Industrial and Corporate Change*, 17(4), 611–646.
- Chatterji, A. K. (2009). Spawned with a silver spoon? Entrepreneurial performance and innovation in the medical device industry. *Strategic Management Journal*, 30(2), 185–206.
- Choudhury, P., & Haas, M. R. (2018). Scope versus speed: Team diversity, leader experience, and patenting outcomes for firms. *Strategic Management Journal*, 39(4), 977–1002.
- Colombelli, A., Krafft, J., & Vivarelli, M. (2016). To be born is not enough: The key role of innovative start-ups. *Small Business Economics*, 47(2), 277–291.
- Colombo, M., Mustar, P., & Wright, M. (2010). Dynamics of science-based entrepreneurship. *The Journal of Technology Transfer*, 35(1), 1–15.
- Currie, G., Burgess, N., & Hayton, J. C. (2015). HR practices and knowledge brokering by hybrid middle managers in hospital settings: The influence of professional hierarchy. *Human Resource Management*, 54(5), 793–812.
- Dahl, M. S., & Reichstein, T. (2007). Are you experienced? Prior experience and the survival of new organizations. *Industry and Innovation*, 14(5), 497–511.
- Davids, M., & Frenken, K. (2018). Proximity, knowledge base and the innovation process: Towards an integrated framework. *Regional Studies*, 52(1), 23–34.
- de Castro Peixoto, L., Barbosa, R. R., & de Faria, A. F. (2021). Management of regional knowledge: Knowledge flows among university, industry, and government. *Journal of the Knowledge Economy*, 1–19.
- Dell'Anno, D., & Del Giudice, M. (2015). Absorptive and desorptive capacity of actors within university-industry relations: Does technology transfer matter? *Journal of Innovation and Entrepreneurship*, 4(1), 1–20.
- Ding, W. W. (2011). The impact of founders' professional-education background on the adoption of open science by for-profit biotechnology firms. *Management Science*, 57(2), 257–273.
- Dokko, G., Kane, A. A., & Tortoriello, M. (2014). One of us or one of my friends: How social identity and tie strength shape the creative generativity of boundary-spanning ties. *Organization Studies*, 35(5), 703–726.
- Engidaw, A. E. (2021). Exploring entrepreneurial culture and its socio-cultural determinants: In case of Woldia University graduating students. *Journal of Innovation and Entrepreneurship*, 10(1), 1–15.
- Etzkowitz, H., Webster, A., Gebhardt, C., & Terra, B. R. C. (2000). The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm. *Research Policy*, 29(2), 313–330.
- Ewenstein, B., & Whyte, J. (2007). Beyond words: Aesthetic knowledge and knowing in organizations. *Organization Studies*, 28(5), 689–708.
- Fabrizio, K. R. (2009). Absorptive capacity and the search for innovation. *Research Policy*, 38(2), 255–267.

- Farinha, L., Ferreira, J., & Gouveia, B. (2016). Networks of innovation and competitiveness: A triple helix case study. *Journal of the Knowledge Economy*, 7(1), 259–275.
- Fenters, V., Balven, R. M., Waldman, D. A., & Siegel, D. (2017). Identity hierarchies of academic entrepreneurs: Moving beyond dyadic comparisons. In *Academy of Management Proceedings* (Vol. 2017, No. 1, p. 13936). Briarcliff Manor, NY 10510: Academy of Management.
- Feola, R., Parente, R., & Cucino, V. (2021). The entrepreneurial university: How to develop the entrepreneurial orientation of academia. *Journal of the Knowledge Economy*, 12(4), 1787–1808.
- Fini, R., Rasmussen, E., Siegel, D., & Wiklund, J. (2018). Rethinking the commercialization of public science: From entrepreneurial outcomes to societal impacts. *Academy of Management Perspectives*, 32(1), 4–20.
- Fisher, D., & Atkinson-Grosjean, J. (2002). Brokers on the boundary: Academy-industry liaison in Canadian universities. *Higher Education*, 44(3), 449–467.
- Francis, B., Hasan, I., & Wu, Q. (2015). Professors in the boardroom and their impact on corporate governance and firm performance. *Financial Management*, 44(3), 547–581.
- Ghio, N., Guerini, M., Lehmann, E. E., & Rossi-Lamastra, C. (2015). The emergence of the knowledge spillover theory of entrepreneurship. *Small Business Economics*, 44(1), 1–18.
- Gieryn, T. F. (1983). Boundary-work and the demarcation of science from non-science: Strains and interests in professional ideologies of scientists. *American Sociological Review*, 48(6), 781–795.
- Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17(S2), 109–122.
- Guerrero, M., & Urbano, D. (2014). Academics' start-up intentions and knowledge filters: An individual perspective of the knowledge spillover theory of entrepreneurship. *Small Business Economics*, 43(1), 57–74.
- Guo, F., Restubog, S. L. D., Cui, L., Zou, B., & Choi, Y. (2019a). What determines the entrepreneurial success of academics? Navigating multiple social identities in the hybrid career of academic entrepreneurs. *Journal of Vocational Behavior*, 112, 241–254.
- Guo, F., Zou, B., Guo, J., Shi, Y., Bo, Q., & Shi, L. (2019b). What determines academic entrepreneurship success? A social identity perspective. *International Entrepreneurship and Management Journal*, 15(3), 929–952.
- Guo, Y., Qiao, J., & Guo, H. (2021). The influence of executives' academic experience on corporate social responsibility performance: Based on imprinting theory. *Human Resource Development of China*, 38(5), 84–100.
- Hahn, D., Minola, T., & Eddleston, K. A. (2019). How do scientists contribute to the performance of innovative start-ups? An imprinting perspective on open innovation. *Journal of Management Studies*, 56(5), 895–928.
- Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, 9(2), 193–206.
- Hmieleski, K. M., & Powell, E. E. (2018). The psychological foundations of university science commercialization: A review of the literature and directions for future research. *Academy of Management Perspectives*, 32(1), 43–77.
- Jonsson, L., Baraldi, E., Larsson, L. E., Forsberg, P., & Severinsson, K. (2015). Targeting academic engagement in open innovation: Tools, effects and challenges for university management. *Journal of the Knowledge Economy*, 6(3), 522–550.
- Judge, W. Q., Witt, M. A., Zattoni, A., Talaucar, T., Chen, J. J., Lewellyn, K., & Van Ees, H. (2015). Corporate governance and IPO underpricing in a cross-national sample: A multilevel knowledge-based view. *Strategic Management Journal*, 36(8), 1174–1185.
- Kassicieh, S. (2010). The knowledge economy and entrepreneurial activities in technology-based economic development. *Journal of the Knowledge Economy*, 1(1), 24–47.
- Katila, R., & Ahuja, G. (2002). Something old, something new: A longitudinal study of search behavior and new product introduction. *Academy of Management Journal*, 45(6), 1183–1194.
- Knockaert, M., Ucbasaran, D., Wright, M., & Clarysse, B. (2011). The relationship between knowledge transfer, top management team composition, and performance: The case of science-based entrepreneurial firms. *Entrepreneurship Theory and Practice*, 35(4), 777–803.
- Kuo, C. I., Wu, C. H., & Lin, B. W. (2019). Gaining from scientific knowledge: The role of knowledge accumulation and knowledge combination. *R&D Management*, 49(2), 252–263.
- Lam, A. (2018). Boundary-crossing careers and the 'third space of hybridity': Career actors as knowledge brokers between creative arts and academia. *Environment and Planning a: Economy and Space*, 50(8), 1716–1741.

- Lam, A. (2020). Hybrids, identity and knowledge boundaries: Creative artists between academic and practitioner communities. *Human Relations*, 73(6), 837–863.
- Laperche, B., & Liu, Z. (2013). SMEs and knowledge-capital formation in innovation networks: A review of literature. *Journal of Innovation and Entrepreneurship*, 2(1), 1–16.
- Los, B., & Verspagen, B. (2007). Technology spillovers and their impact on productivity. In: H. Hanusch & A. Pyka, (Eds.). *Elgar company to neo-Schumpeterian economics*, Edward Elgar Publishing, Chapter 35.
- Makri, M., Hitt, M. A., & Lane, P. J. (2010). Complementary technologies, knowledge relatedness, and invention outcomes in high technology mergers and acquisitions. *Strategic Management Journal*, 31(6), 602–628.
- Mannucci, P. V., & Yong, K. (2018). The differential impact of knowledge depth and knowledge breadth on creativity over individual careers. *Academy of Management Journal*, 61(5), 1741–1763.
- Marozau, R., Guerrero, M., & Urbano, D. (2021). Impacts of universities in different stages of economic development. *Journal of the Knowledge Economy*, 12(1), 1–21.
- Mathisen, M. T., & Rasmussen, E. (2019). The development, growth, and performance of university spin-offs: A critical review. *The Journal of Technology Transfer*, 44(6), 1891–1938.
- McMillan, G. S., Narin, F., & Deeds, D. L. (2000). An analysis of the critical role of public science in innovation: The case of biotechnology. *Research Policy*, 29(1), 1–8.
- Meng, D., Li, X., & Rong, K. (2019). Industry-to-university knowledge transfer in ecosystem-based academic entrepreneurship: Case study of automotive dynamics & control group in Tsinghua University. *Technological Forecasting and Social Change*, 141, 249–262.
- Meyer, M. (2002). Tracing knowledge flows in innovation systems. *Scientometrics*, 54(2), 193–212.
- Miller, K., Alexander, A., Cunningham, J. A., & Albats, E. (2018). Entrepreneurial academics and academic entrepreneurs: A systematic literature review. *International Journal of Technology Management*, 77(1–3), 9–37.
- Minola, T., Hahn, D., & Cassia, L. (2021). The relationship between origin and performance of innovative start-ups: The role of technological knowledge at founding. *Small Business Economics*, 56(2), 553–569.
- Mishra, S., & Tripathi, A. R. (2021). AI business model: An integrative business approach. *Journal of Innovation and Entrepreneurship*, 10(1), 1–21.
- Moorthy, S., & Polley, D. E. (2010). Technological knowledge breadth and depth: Performance impacts. *Journal of Knowledge Management*, 14(3), 359–377.
- Murnieks, Y. C., Haynie, M. J., & Wiltbank, R. (2014). Pathways of passion. *Journal of Management*, 40(6), 1583–1606.
- Niedderer, K., & Reilly, L. (2010). Research practice in art and design: Experiential knowledge and organised inquiry. *Journal of Research Practice*, 6(2), E2–E2.
- Özman, M. (2007). Breadth and depth of main technology fields: An empirical investigation using patent data. *Middle East Technological University working paper*.
- Pancholi, S., Yigitcanlar, T., & Guaralda, M. (2014). Urban knowledge and innovation spaces: Concepts, conditions and contexts. *Asia Pacific Journal of Innovation and Entrepreneurship*, 8(1), 15–38.
- Partha, D., & David, P. A. (1994). Toward a new economics of science. *Research Policy*, 23(5), 487–521.
- Powell, W. W., & Sandholtz, K. W. (2012). Amphibious entrepreneurs and the emergence of organizational forms. *Strategic Entrepreneurship Journal*, 6(2), 94–115.
- Prabhu, J. C., Chandu, R. K., & Ellis, M. E. (2005). The impact of acquisitions on innovation: Poison pill, placebo, or tonic? *Journal of Marketing*, 69(1), 114–130.
- Purchase, S., Ellis, N., Mallett, O., & Theingi, T. (2018). Religious social identities in the hybrid self-presentations of Sikh Businesspeople. *British Journal of Management*, 29(1), 99–117.
- Riad Shams, S. M., & Belyaeva, Z. (2019). Quality assurance driving factors as antecedents of knowledge management: A stakeholder-focussed perspective in higher education. *Journal of the Knowledge Economy*, 10(2), 423–436.
- Rorwana, A., & Tenenge, R. K. (2015). The role of academic entrepreneurs in the process of technology transfer and commercialization: The case of a University of Technology in South Africa. *Environmental Economics*, 6(4), 25–37.
- Rypestøl, J. O. (2017). Regional industrial path development: The role of new entrepreneurial firms. *Journal of Innovation and Entrepreneurship*, 6(1), 1–19.
- Sapir, A. (2021). Brokering knowledge, monitoring compliance: Technology transfer professionals on the boundary between academy and industry. *Journal of Higher Education Policy and Management*, 43(3), 248–263.

- Sauermann, H., & Roach, M. (2012). Taste for science, taste for commercialization, and hybrid scientists. In *34th DRUID Celebration Conference*.
- Sauermann, H., & Stephan, P. E. (2010). *Twins or strangers? Differences and similarities between industrial and academic science* (No. w16113). National Bureau of Economic Research.
- Sharker, Z. A., Van de Velde, E., & Larraneta, B. (2007). Knowledge conversion capability and the performance of corporate and university spin-offs. *Industrial and Corporate Change*, *16*(4), 569–608.
- Shi, Y., Zou, B., & Santos, R. S. (2021). Dr. Jekyll and Mr. Hyde: How do academic entrepreneurs deal with identity conflict?. *Review of Managerial Science*, *15*(8), 2165–2191.
- Stephan, P. E. (1996). The economics of science. *Journal of Economic Literature*, *34*(3), 1199–1235.
- Suman, L., & Maria, B. (2014). Technological breadth and depth of knowledge in innovation: The role of mergers and acquisitions in biotech. *Industrial and Corporate Change*, *24*(2), 383–415.
- Svare, H. (2016). User-producer dialogue, workplace innovation, and knowledge in a Regional Innovation System. *Journal of the Knowledge Economy*, *7*(2), 565–586.
- Uhm, C. H., Sung, C. S., & Park, J. Y. (2018). Understanding the accelerator from resources-based perspective. *Asia Pacific Journal of Innovation and Entrepreneurship*, *12*(3), 258–278.
- Ulhøi, J. P. (2021). From innovation-as-usual towards unusual innovation: Using nature as an inspiration. *Journal of Innovation and Entrepreneurship*, *10*(1), 1–21.
- Visintin, F., & Pittino, D. (2014). Founding team composition and early performance of university—Based spin-off companies. *Technovation*, *34*(1), 31–43.
- Volberda, H. W., Foss, N. J., & Lyles, M. A. (2010). Perspective—Absorbing the concept of absorptive capacity: How to realize its potential in the organization field. *Organization Science*, *21*(4), 931–951.
- Walter, S. G., Schmidt, A., & Walter, A. (2016). Patenting rationales of academic entrepreneurs in weak and strong organizational regimes. *Research Policy*, *45*(2), 533–545.
- Wang, M., Soetanto, D., Cai, J., & Munir, H. (2022). Scientist or Entrepreneur? Identity centrality, university entrepreneurial mission, and academic entrepreneurial intention. *The Journal of Technology Transfer*, *47*(1), 119–146.
- Wang, Q., & von Tunzelmann, N. (2000). Complexity and the functions of the firm: Breadth and depth. *Research Policy*, *29*(7–8), 805–818.
- Wathanakom, N., Khlaisang, J., & Songkram, N. (2020). The study of the causal relationship between innovativeness and entrepreneurial intention among undergraduate students. *Journal of Innovation and Entrepreneurship*, *9*(1), 1–13.
- Wright, M., Hmieleski, K. M., Siegel, D. S., & Ensley, M. D. (2007). The role of human capital in technological entrepreneurship. *Entrepreneurship Theory and Practice*, *31*(6), 791–806.
- Yusof, M., & Jain, K. K. (2009). Entrepreneurial leadership and academic entrepreneurship in Malaysian public research universities. *Asia Pacific Journal of Innovation and Entrepreneurship*, *3*(3), 63–84.

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## Authors and Affiliations

Yuanyuan Chen<sup>1</sup> · Wei Liu<sup>1</sup> · Stavros Sindakis<sup>2</sup>  · Sakshi Aggarwal<sup>3</sup>

Yuanyuan Chen  
chenyuanyuan@cqu.edu.cn

Stavros Sindakis  
sindakis.stavros@ac.eap.gr

Sakshi Aggarwal  
s.aggarwal@iseeg.org

<sup>1</sup> School of Economics and Business Administration, Chongqing University, Chongqing, China

<sup>2</sup> School of Social Sciences, Hellenic Open University, 18 Aristotelous Street, Patras 26335, Greece

<sup>3</sup> Institute of Strategy, Entrepreneurship and Education for Growth, Athens, Greece