OPEN ACCESS
International Journal of Innovation and Technology Management
Vol. 18, No. 4 (2021) 2150016 (30 pages)

DOI: 10.1142/S0219877021500164

World Scientific
www.worldscientific.com

Impact of Self-Regulated Learning on Entrepreneurial Opportunity Recognition and Academic Entrepreneurship Performance

Noorlizawati Abd Rahim*, Zainai Mohamed, Astuty Amrin
and Maslin Masrom

Razak Faculty of Technology and Informatics
Universiti Teknologi Malaysia
54100, Kuala Lumpur Malaysia
**noorlizawati@utm.my*

Received 28 September 2020
Revised 15 March 2021
Accepted 23 March 2021
Published 28 June 2021

The ratio of academic scientists to the labor force in Malaysia has increased. However, the contribution of academic scientists to commercialize research discoveries remains limited. Successful research commercialization or university technology transfer requires entrepreneurial effort that may involve skills beyond the traditional roles of academics. The ability to identify the commercial opportunity of research, i.e. entrepreneurial opportunity recognition, has been proven to be a critical skill for an academic entrepreneur. Earlier findings in this area would have been far more useful if the antecedents of entrepreneurial opportunity recognition were recognized. Although self-regulated learning has been inferred to as informal entrepreneurship education for academic entrepreneurs, there has been a lack of evidence on how it influences their academic entrepreneurship performance. This paper examined the characteristics of academic entrepreneurs and the key success factors, whether academics' opportunity recognition ability is influenced by their self-regulated learning behavior. A quantitative research design was employed based on a case study of a technological university in Malaysia involving 115 academic entrepreneurs. Structural equation modeling analysis results revealed that academics' opportunity recognition and social capital are the most important determinants of their academic entrepreneurship performance. The efficiency of the Technology Transfer Office and the ease of securing funding play influential roles too, but to a smaller extent. Most importantly, opportunity recognition is strengthened by self-regulated learning, through frequent deliberate practices in information and knowledge seeking that enable scientists to be more creative and innovative in translating research into marketable products and technology.

Keywords: Academic entrepreneur; funding; opportunity recognition; self-regulated learning; research commercialization; technology transfer office; university technology transfer.

---

*Corresponding author.

1. Introduction

A competitive environment with a shrinking research budget has led the shift of higher education institutions from ivory towers to entrepreneurial universities [Audretsch *et al.* (2015); Etzkowitz (2016)]. This shift is also driven by the significant contribution of academic research to a nation's gross domestic product [Guerrero *et al.* (2015); Iacobucci and Micozzi (2015); Vincett (2010)]. Consequently, the traditional roles of higher education in teaching and research have now been extended to include academic entrepreneurship [Barth and Schlegelmilch (2013); Wood (2011)]. However, the 2014 Global Entrepreneurship Monitor (GEM) report highlighted a gap in entrepreneurial activity rates between Malaysia and other countries [Roland *et al.* (2011); Singer *et al.* (2015)], even though the total number of academic scientists in Malaysia increased four-fold over the six-year period since 2006 [MASTIC (2013)]. Recent data also showed that R&D transfer is highly insufficient under Malaysia's current entrepreneurial framework conditions [GEM (2020)]. These gaps exist partly due to academic scientists' limited contribution to commercialize research discoveries and their lack of involvement in academic entrepreneurship.

Academic entrepreneurs are academic scientists who are involved in research commercialization or university technology transfer activities. Academic scientists are deemed key factors whose research works lead to discoveries with commercial potential [Jain *et al.* (2009); Wood (2011)]. Nonetheless, such entrepreneurial pursuit is beyond their scientific expertise and traditional roles [Franklin *et al.* (2001); Wright *et al.* (2007)]. The endeavor to bring innovation from the lab to the market inherently demands a long gestation period and pits academic scientists against unknown challenges due to their lack of entrepreneurship skills and knowledge. Regardless of these pessimistic claims, there have been successful cases of academic entrepreneurs [Closs *et al.* (2013); Petkewich (2009); Rahim *et al.* (2015)].

An investigation of the relationship between scientists' entrepreneurial characteristics and their academic entrepreneurship performance is imperative to unfold the skills and behaviors that enable them to become more entrepreneurial than their colleagues. Opportunity recognition, or the ability to identify the commercial opportunity of research, has been proven as a critical skill of an academic entrepreneur [Clarysse *et al.* (2011)]. However, earlier findings in this area would have been far more useful if the antecedents of entrepreneurial opportunity recognition ability had been recognized. The answers to why and how some individuals are capable to identify opportunity have always been associated to prior knowledge and thinking process that contribute to their enhanced alertness to entrepreneurial opportunity [Hajizadeh and Zali (2016)]. Indeed, numerous studies have been focused on uncovering the cognitive functioning that contribute to individual's ability to recognize opportunity easily and successfully [Kuckertz *et al.* (2017); Mitchell *et al.* (2002); Santos *et al.* (2015)]. For instance, entrepreneurial learning is a dynamic and self-regulated process that contribute towards entrepreneurial success [Fust *et al.* (2017)]. Although self- regulated learning has been thought to act as an informal entrepreneurship education to academic entrepreneurs [Feldmann (2014)], there has been a lack of evidence on how it influences their academic entrepreneurship performance. The main aim of this study is thus to determine the relationship between academic entrepreneurs' self-regulated learning and their ability to identify the commercial opportunity of research discoveries.

Research pertaining the determinants of research commercialization success has been a continuing concern within the field of academic entrepreneurship. The literature would have been far more comprehensive if the under-researched effects of scientists' entrepreneurial characteristics and institutional culture [Kirchberger and Pohl (2016)] had been examined concurrently with institutional support. As policy implementation should be relevant to the university context [Wright *et al.* (2012)], an evaluation of the effectiveness of the infrastructure support system is another beneficial purpose of this study.

2. Literature Review

2.1. *Entrepreneurial activity in the university*

Academic entrepreneurship is a concept that embodies the idea of an entrepreneurial university [Barth and Schlegelmilch (2013); Gibb and Hannon (2006); Wood (2011)] and is often associated with the commercialization of new knowledge generated from academic research discoveries. Siegel and Wright [2015] defined academic entrepreneurship as the initiatives undertaken by a university to stimulate commercialization within academia. Similarly, Grimaldi *et al.* [2011] denoted it as technological entrepreneurship via a university's effort to commercialize academic scientists' research findings or innovations through activities like patenting, licensing, spin-off creation, and university-industry partnership. In addition, Wood [2011] described it as the efforts and activities undertaken by a university and its industry partners to commercialize discoveries from research. On the other hand, Yusof *et al.* [2010] perceive academic entrepreneurship as a value creation process that involves organizational innovation through patenting, licensing, and design rights as well as organizational creation through spin-offs and joint ventures. They further suggested that this process also involves organizational renewal through research groups, research centers, and technology transfer schemes. Altogether, this value creation process leads to the commercialization of research and technology originating from the university. Accordingly, entrepreneurial activities in university reinforce the bond between universities and industry that bring significant impact to the regional and social development [Pattnaik and Pandey (2016)].

Siegel and Wright [2015], in their work advocating the rethinking of academic entrepreneurship, claimed that the benchmarking of entrepreneurial activities based on the metrics of patenting, licensing, and start-up activity (as in the United States and Canada) may not represent the true outcomes of academic entrepreneurship. Furthermore, these traditional indicators often require a long gestation period to materialize [Reynolds *et al.* (2004)]. This presents challenges in gauging the progress of entrepreneurial activity, especially for universities that are novices in academic entrepreneurship. Therefore, this study examined the academic entrepreneurship

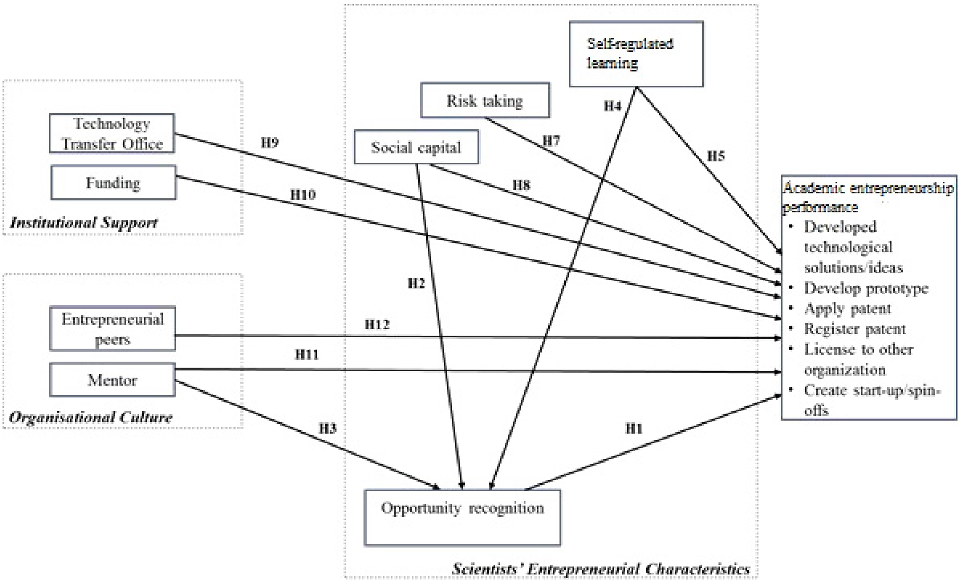

Fig. 1. Conceptual framework.

performance of academic entrepreneurs on a much wider spectrum by including the progress in developing commercial opportunities (e.g. technological solution ideas and potential prototypes) in addition to the other academic entrepreneurship performance indicators depicted in Fig. 1. Accordingly, the term "academic entrepreneurship performance" in this study refers to entrepreneurial activities undertaken by academic scientists in their quest to commercialize research or transfer technology-based innovation from academia to external organizations that utilize and apply the technology for marketable products [Kirchberger and Pohl (2016); Mom *et al.* (2012)].

2.2. *Opportunity recognition*

Opportunity recognition is one of the key foundational concepts in entrepreneurship research [Chell (2013)] that explains why some individuals become entrepreneurs and some do not [Shane and Venkataraman (2000)]. Although scholars have long debated opportunity recognition [George *et al.* (2014)], this concept has not been extensively examined from the academic entrepreneurship perspective. The few notable exceptions have acknowledged academic entrepreneurship as a process arising from opportunity recognition [d'Este *et al.* (2012); Prodan and Drnovsek (2010)]. Opportunity recognition refers to the ability of an academic entrepreneur to detect opportunities from research that can be converted into commercial market applications [Clarysse *et al.* (2011); Fernández-Pérez *et al.* (2015); Rasmussen and Rice (2011)]. Prior evidence suggests that academic scientists who have a stronger self-belief in their opportunity recognition ability have a higher entrepreneurial intention to create a start-up company by transferring technology related to research discoveries [Fernández-Pérez *et al.* (2015)]. Similarly, Clarysse *et al.* [2011] showed that academic scientists with a higher degree of opportunity recognition capability are more likely to create ventures themselves. Accordingly, this study proposed the following hypothesis:

H1: *Scientists' ability to identify the commercial opportunity of academic research relates positively to their academic entrepreneurship performance*

A common theme in most studies on the antecedents of opportunity recognition has been the crucial role of information in preceding this process. Generally, there are two main reasons why some individuals can recognize opportunity [Casson (2005)]. First, these individuals have better information. Second, they can put that information to better use towards value creation. The influence of information in the opportunity recognition process raises the question of how individuals can get better information. In this regard, connections with diverse people provides access to external knowledge [Ramos-Rodríguez *et al.* (2010)], whereby the strength of the social network between entrepreneurs, managers, and entrepreneurial associations influences the number of opportunities an individual can develop and exploit [Fuentes *et al.* (2010)]. In addition, Fernández-Pérez *et al.* [2015] adopted a broader perspective to investigate the indirect influence of academic scientists' distinct social networks (professional forums and business and personal networks) on entrepreneurial intention. Their analysis of 630 Spanish scientists provided evidence on the positive effect of perceived informational support from business and personal networks on scientists' higher self-belief in opportunity recognition. In the same manner, the presence of entrepreneurial mentors among senior academics may also bestow scientists with relevant information, which in turn facilitates opportunity recognition. Evidence in sustainable entrepreneurship revealed that entrepreneurs' opportunity recognition is influenced by their knowledge of natural and communal environments that provide them with the edge of having additional information [Hanohov and Baldacchino (2018)]. Hence, this study predicted as follows:

H2: *Scientists' social capital relates positively to their ability to identify the commercial opportunity of academic research*

H3: *Influence from mentors to provide informational support relates positively to scientists' ability to identify the commercial opportunity of academic research*

H13: *Scientists' social capital indirectly relates to academic entrepreneurship performance through their ability to identify the commercial opportunity of academic research*

2.3. *Self-regulated learning*

Theoretically, self-regulated learning is an independent learning approach that requires an individual to (i) take his/her own initiative in identifying learning needs to achieve a certain goal and (ii) acquire learning resources with or without the assistance of others [Brookfield (2009)].

The idea of self-regulated learning parallels with the entrepreneurial personality literature, which suggests that behavioral characteristic of entrepreneurs involves autonomous and strategic actions to identify and organize resources for the purpose of converting opportunities to marketable products [Chell *et al.* (1991); Cromie (2000)]. Furthermore, self-regulated learning behavior allows entrepreneurs to take accountability and to control both self-monitoring and self-management processes in achieving specific learning goals [Tseng (2013)].

Academic scientists generally lack business-related knowledge and are relatively unfit for entrepreneurial tasks [Franklin *et al.* (2001)]. In the pursuit of research commercialization and technology transfer, scientists encounter knowledge gaps due to their unfamiliarity with entrepreneurship, as being an entrepreneur goes beyond their traditional roles and scientific expertise. In facing the conditions of uncertainty, scientists must self-regulate their behavior, environment and cognition within the entrepreneurial context. Even though they may start as novices, their capability can be developed through self-regulated learning [Winkler *et al.* (2016)]. This study argues that scientists who step out of their comfort zones and attempt to accomplish self-regulated learning to bridge these knowledge gaps will potentially make the difference. Specific environmental features beyond comfort zone enable entrepreneur to build up diverse skills and network relations conducive to entrepreneurship that led to opportunities discovery [Schlepphorst *et al.* (2020)]. Besides, entrepreneurs also learn to develop opportunity recognition through market interaction and real-life process formed by prior knowledge, accumulated resources and industrial contexts [Sanz-Velasco (2006)]. Accordingly, this study defines scientists' entrepreneurial effort in self-regulated learning as determined attempts to acquire and organize resources related to academic entrepreneurship with the explicit goal of transferring technologies from academic research.

In their attempts to realize successful research commercialization, scientists may independently learn about research ideas and opportunities by attending conferences and university-run product exhibitions. The source of scientists' self-regulated learning may also come from discussions with industrial contacts about problems that can potentially be resolved through research [Thursby and Thursby (2001)]. Furthermore, Smilor [1997, p. 344] asserted that "*effective entrepreneurs are exceptional learners who learn by doing and learn from everything including customers, suppliers, and competitors*". Therefore, scientists' self-regulated learning may also be accomplished through their active seeking of information from potential customers, suppliers, competitors, investors, business partners, as well as other organizations. These autonomous efforts in entrepreneurial learning allow scientists to gather external information that exposes them to more ideas and opportunities, which may influence their opportunity recognition ability. Hence, this study conjectured as follows:

H4: *Scientists' self-regulated learning relates positively to their ability to identify the commercial opportunity of academic research*

H5: *Scientists' self-regulated learning relates positively to their academic entrepreneurship performance*

H6: *Scientists' self-regulated learning indirectly relates to academic entrepreneurship performance through their ability to identify the commercial opportunity of academic research*

2.4. *Risk-taking*

It has long been argued that entrepreneurs have a risk-taking trait [Brockhaus (1980); Nielsen (2015)], which is a measure of the degree to which individuals are willing to make huge and risky resource commitments to seize opportunities with high chances of costly failure [Kirkman (2013)]. Fear of failure influences one's decision to engage in entrepreneurial activity, given that venturing into a new business poses the risk of financial losses that may affect one's future and emotional state [Xavier *et al.* (2012)]. Scientists often encounter uncertainty regarding the usefulness of technology as well as its commercial application and replication in the industry since technology is usually transferred at the infancy stage [Jensen and Thursby (2003)]. Therefore, academic entrepreneurs are those who bold enough to embrace these risks [Fernández-Pérez *et al.* (2015); Guerrero *et al.* (2008)]. Accordingly, this study predicted the following hypothesis:

H7: *The risk-taking propensity of scientists positively relates to their academic entrepreneurship performance*

2.5. *Social capital*

Social capital is described as "*resources individuals obtain from knowing others, being part of a social network with them, or merely from being known to them*" [Baron and Markman (2000, p. 10)]. In the academic context, these social networks involve personal, professional, and business linkages between scientists and other individuals. A large body of literature has focused on the contribution of social capital to academic entrepreneurship, specifically to the formation of entrepreneurial intention [Aldridge and Audretsch (2011); Fernández-Pérez *et al.* (2015); Karlsson and Wigren (2012); Landry *et al.* (2006); Prodan and Drnovsek (2010); Sequeira *et al.* (2007)] to opportunity recognition and start-up survival [Pugalia *et al.* (2020)]. Scientists benefit from their social network in terms of both the tangible and intangible resources needed for technology transfer. For instance, apart from enhancing informational access to business markets, new opportunities [Prodan and Drnovsek (2010)] and consumer needs [Fernández-Pérez *et al.* (2015)], social capital also provides scientists with technical support [Karlsson and Wigren (2012); Ozgen and Baron (2007)], emotional support [Fernández-Pérez *et al.* (2015)], and financial resources [Baron and Markman (2000)]. In accordance with these considerations, this study hypothesized:

H8: *Scientists' social capital positively relates to their academic entrepreneurship performance*

2.6. *Institutional support*

2.6.1. *Technology transfer office*

The establishment of a Technology Transfer Office (TTO) is a major area of interest within the field of academic entrepreneurship [Grimaldi *et al.* (2011); Siegel and

Wright (2015)] as universities continue to play crucial role to develop and enhance their capabilities to support the growth of technology-based new ventures [Rao and Mulloth (2017)]. The term TTO in this study refers to assistance and support measures provided by a university entity to facilitate academic entrepreneurs in research commercialization and technology transfer. Some scholars attested that the establishment of TTO has impacted the performance of academic entrepreneurship [Clarysse *et al.* (2011); Muscio *et al.* (2016); Nosella and Grimaldi (2009); Phan *et al.* (2005); Rizzo and Ramaciotti (2014)]. However, there have been contradictory evidence to this [Clarysse *et al.* (2011)]. For instance, Nosella and Grimaldi [2009] revealed no direct linkage between a TTO's establishment and the number of start-ups. This inconsistent observation could be due to inhomogeneity of TTO across different universities [Markman *et al.* (2005)] that impact universities in a dissimilar manner [Aldridge and Audretsch (2011)].

Recent studies have instead attempted to explain the influences of a TTO's size [Aldridge and Audretsch (2011); Muscio *et al.* (2016)], resources [Osiri *et al.* (2013)] and efficiency [Aldridge and Audretsch (2011); Clarysse *et al.* (2011)] on the development of academic entrepreneurship. Institutional support from a TTO to academic entrepreneurs through its collective services is critical [Rasmussen and Wright (2015)], especially in the early stages of technology transfer [Rasmussen and Rice (2011); Wood (2011)]. However, the specific types of TTO services that are conducive to scientists' academic entrepreneurship performance remain unclear. For instance, an examination of 128 universities' TTOs showed that their mission statements prioritize licensing for royalties and intellectual property (IP) protection more than facilitating scientists in the disclosure process [Markman *et al.* (2005)]. This study argues that if a TTO is effective, its presence should have a positive impact on scientists' involvement in entrepreneurial activity and their consequent academic entrepreneurship performance. Accordingly, this study predicted the following:

H9: *The efficiency of a Technology Transfer Office positively relates to scientists' academic entrepreneurship performance*

2.6.2. *Funding*

A growing body of literature recognizes the importance of financial assistance in the early stages of a technology transfer pursuit [Kochenkova *et al.* (2015); Rasmussen and Sørheim (2012)]. Through the provision of proof-of-concept funds, translational funds, or pre-seeds funds, the financial gap between research and commercialization is bridged, freeing scientists from having to redistribute research and development (R&D) funds. Moreover, proper funding of research discoveries with commercial potential allows scientists to proceed with proofs-of- concept, enter the market, and seize opportunities at the right time without postponing a technology's potential [Gubitta *et al.* (2016)]. While there is evidence on the positive effect of funding amount on the entrepreneurial activity rate [Aldridge and Audretsch (2011); O'shea *et al.* (2005); Rasmussen *et al.* (2006); Rizzo and Ramaciotti (2014)], some studies have observed contrary findings [Di Gregorio and Shane (2003)]. For instance, Stanford University, with a sponsored research expenditure of USD 391 million, managed to generate 25 start-ups while Duke University, with a sponsored research expenditure of USD 361 million, did not generate any [Di Gregorio and Shane (2003)]. The inconsistency of these findings raises the question of whether it is the complexity of funding procedures that matters rather than the amount of funding. Therefore, this study hypothesized as follows:

H10: *The ease of getting financial assistance positively relates to scientists' academic entrepreneurship performance*

2.7. *Organizational culture*

2.7.1. *Mentor support*

Variations in entrepreneurial activity rates [Di Gregorio and Shane (2003)] may be attributed to differences in entrepreneurial cultures at organizational and faculty levels [Osiri *et al.* (2013); Tartari *et al.* (2014)]. Social norms influence scientists' entrepreneurial behavior [Ajzen (1991)] when most faculty members embrace attitudes, values, goals, and practices favoring entrepreneurship [Osiri *et al.* (2013)]. Indeed, organizational culture is the closest environmental factor that affects scientists' engagement in entrepreneurial activity [Bercovitz and Feldman (2008); Huyghe *et al.* (2015); Prodan and Drnovsek (2010); Tartari *et al.* (2014)].

Leadership direction [Bercovitz and Feldman (2008)] and interaction with other faculty members [Osiri *et al.* (2013)] are two elements that establish culture, which subsequently impels the attitude of a scientist towards academic entrepreneurship. Senior management support and culture that encourage cooperation across organizational boundaries have also been found to contribute towards a successful commercialization and technology transfer in the public-private cooperation [Geisler and Turchetti (2015)]. Furthermore, the presence of a mentor to confer knowledge and support relating to academic entrepreneurship may persuade scientists on the feasibility of an entrepreneurial pursuit. Indeed, a study on the learning development of novice entrepreneurs indicated positive learning outcomes from mentorship programs [St-Jean and Audet (2012)]. This is because formal mentoring program can effectively strengthen mentee's entrepreneurial self-efficacy through support from mentors [St-Jean *et al.* (2018)].

Accordingly, this study predicted the following:

H11 *Support from mentor positively relates to scientists' academic entrepreneurship performance*

2.8. *Entrepreneurial peers*

The entrepreneurial peer effect reflects scientists' interaction with other faculty members who have prior experience in technology transfer. This effect inspires scientists to become academic entrepreneurs [Tartari *et al.* (2014)], especially if they have low exposure to entrepreneurship [Nanda and Sørensen (2010)]. Similar to

Prodan and Drnovsek [2010], Huyghe *et al.* [2015] provided evidence that the presence of colleagues who have been involved in spin-off creation, patenting, licensing, contract research, or consulting positively affects scientists' propensity to engage in technology transfer activities. This is partly because entrepreneurial peers deliver the message that their dual roles as academics and entrepreneurs are socially accepted, which in turn enhances scientists' perceived desirability towards research commercialization and technology transfer pursuits [Ajzen (1991)]. Indeed, a recent study on the power of peers reveals that encouragement from peers strengthen the relationship between creativity and entrepreneurial intention [Bello *et al.* (2018)]. Besides, risk-averse scientists may be relieved of the stigma of failure after learning from their entrepreneurial peers' experiences [Nanda and Sørensen (2010)]. Therefore, this study predicted the following:

H12: *The presence of entrepreneurial peers among colleagues positively relates to scientists' academic entrepreneurship performance*

Figure 1 summarizes this study's conceptual framework, indicating the expected relationships between scientists' entrepreneurial characteristics (opportunity recognition, self-regulated learning, risk-taking, social capital), institutional support (TTO efficiency, ease of getting funding), organizational culture (mentors, entrepreneurial peers), and academic entrepreneurship performance.

3. Methodology

The study sample consisted of academic scientists from a public research university in Malaysia, i.e. Universiti Teknologi Malaysia (UTM). Statistics show that local commercial products and technologies originating from academic research are mostly contributed by the engineering sciences [MASTIC (2013b)], implying that academic entrepreneurs are more common among scientists from the engineering field [Reguera (2016); Philpott *et al.* (2011); Zhang *et al.* (2014)]. Therefore, the selection of UTM as a case study was justified given that its primary focus is the teaching and research of engineering [UTM Organisational Management Division (2016)]. However, despite its core establishment for engineering teaching and research, UTM lags behind Universiti Sains Malaysia (USM) and Universiti Malaya (UM) in its contribution to commercialize local products and technologies [MASTIC (2013b)]. The number of active scientists in UTM is almost comparable to USM and is higher than UM [MASTIC (2015b)], suggesting that UTM's low performance is due to the limited contribution of its engineering scientists to the commercialization of research discoveries. Based on these considerations, the population of engineering scientists investigated in this study was derived from UTM.

Pertaining to research relating to the determinants of scientists' opportunity recognition capacity and engagement in technology transfer, there has been a significant body of literature, known variables and existing theories to support the work undertaken in this area of interest. Hence, the positivism research paradigm was adopted as it focuses on the quantitative descriptors [Creswell (2003); Dawson

Table 1. Profile of respondents.

	Frequency	Percentage
Gender		
Male	83	72.2
Female	32	27.8
Research Experience		
Below 10 years	19	16.5
10 to 20 years	31	27
20 to 30 years	39	33.9
More than 30 years	26	22.6
Faculty		
Chemical Engineering	13	11.3
Civil Engineering	24	20.9
Electrical & Electronic Engineering	22	19.1
Mechanical Engineering	32	27.8
Biosciences & Medical Engineering	5	4.4
Chemistry	4	3.5
Computer Science	3	2.6
Physics	1	0.9
Geo-Information & Real Estate	9	7.8
Others	2	1.7

(2002)] for this study sought to confirm, support or challenge the findings of other scholars in a different research context. A cross-sectional survey study was employed in this study to develop generalizations to provide better prediction, explanation and understanding of the phenomena under study.

The size of the target population was 1453. A power analysis [Cohen (1988); Hair *et al.* (2014)] using the G*power software [Faul *et al.* (2009)] computed the minimum sample size to be 109, with the maximum number of predictors set at eight, the effect size set at medium (0.15), and the power level set at 0.80 [Gefen *et al.* (2011)]. A survey instrument was developed comprising measurement items for all the variables in this study (see Appendix A). A total of 115 valid responses were received. The demographic profile of the respondents is shown in Table 1. These respondents were a mixture of Professors, Associate Professors and Senior Lecturers. Most of them were from engineering faculties and had more than 10 years of experience.

4. Data Analysis and Results

Hair *et al.* [2014] guided the data analysis in selecting between partial least square (PLS-SEM) and a covariance-based approach (CB-SEM). CB-SEM is not suitable as the goal of this study is neither towards theory testing nor towards comparison of alternative theories. PLS-SEM is considered as the primary approach in this study since the hypothesized model incorporate both formative and reflective constructs. The research model was analyzed using PLS-SEM approach via the SmartPLS 3.0 software [Ringle *et al.* (2015)]. Following the recommended two-stage analytical procedure (Anderson and Gerbing, 1988), the measurement model (validity and reliability of the measures) was tested first, followed by the structural model which examined the hypothesized relationships. The bootstrapping method was used to test the significance of the path coefficients and loadings [Hair *et al.* (2014)].

4.1. *Measurement model evaluation*

The validity and reliability of reflective measures were evaluated in terms of convergent validity, internal consistency, and discriminant validity. Factor loadings, composite reliability (CR), and average variance extracted (AVE) were used to assess convergent validity. The loadings for all reflective items were higher than the acceptable value of 0.5 (see Table 2). The composite reliabilities and AVE values were all higher than 0.7 and 0.5 respectively, exceeding their threshold values. This demonstrated the satisfactory internal consistency reliability and convergent validity of the reflective measurement items.

The discriminant validity of the measures was examined through Fornell and Larcker's [1981] criterion of inter-correlation matrix. As shown in Table 3, the constructs' square root of the AVE (bold values in the diagonals) were higher than the correlations between constructs (values in corresponding rows and columns), indicating adequate discriminant validity. In sum, both convergent and discriminant validity of the reflective measures in this study were established.

The validity of formative measures was evaluated in terms of construct validity, indicator collinearity, and outer weights. For formative measures, a modified multitrait–multimethod (MTMM) matrix analysis [Loch *et al.* (2003)] was employed to assess construct validity [Andreev *et al.* (2009); Lowry and Gaskin (2014)]. Both formative measures established sufficient discriminant validity. The measurement of discriminant validity for these formative measures is discussed in Rahim *et al.* [2019].

The variance inflation factors (VIF) for formative measures were below 3.3 (see Table 2), indicating the absence of multicollinearity. The three indicators with insignificant outer weights were TTO4, SC3, and SC5. Indicator TTO4 was retained as deletion is deemed necessary only if its outer loading is neither significant nor below 0.5 [Hair *et al.* (2014)]. Indicators SC3 and SC5 were also retained as their corresponding outer loadings were above 0.5 and significant. As per the guidelines of Cenfetelli and Bassellier [2009], significant indicators with positive weights were compared based on their magnitudes whereas significant indicators with negative weights (TTO5: efficiency of TTO staff, SC1: professional forums) were interpreted as having negative effects when the effects of other indicators within the same construct were controlled. The results showed the relative effect of all indicators towards the TTO construct was the strongest from TTO2 (commercialization services), followed by TTO1 (awareness programs) and TTO3 (financial planning services). For the social capital construct, the indicator with the strongest effect was SC2 (personal network) followed by SC4 (new partners and potential investors).

4.2. *Structural model evaluation*

The structural model was assessed by evaluating the coefficients of determination (R^2), standardized regression weights (β), and corresponding t-values (see Table 4). The SmartPLS bootstrapping function with 500 resamples was applied to 115 cases.

Table 2. Convergent validity of measurement model.

Type of measures	Construct	Item	Loadings	AVE[a]/Weights[b]	CR	VIF
Reflective measures	Opportunity recognition (OR)	OR1	0.914	0.855	0.959	
		OR2	0.941			
		OR3	0.912			
		OR4	0.932			
	Academic entrepreneurship performance (AEP)	AEP1	0.843	0.551	0.878	
		AEP2	0.521			
		AEP3	0.86			
		AEP4	0.794			
		AEP5	0.712			
		AEP6	0.67			
	Risk taking	RT1	0.881	0.751	0.9	
		RT2	0.918			
		RT3	0.796			
	Mentor support	SM1	0.893	0.776	0.954	
		SM2	0.883			
		SM3	0.834			
		SM4	0.93			
		SM5	0.931			
		SM6	0.808			
	Self-regulated learning	SD2	0.744	0.734	0.951	
		SD3	0.799			
		SD4	0.863			
		SD5	0.912			
		SD6	0.908			
		SD7	0.906			
		SD8	0.854			
	Entrepreneurial peers	EP1	0.95	0.888	0.96	
		EP2	0.949			
		EP3	0.929			
	Funding	FG1	0.824	0.692	0.9	
		FG2	0.83			
		FG3	0.856			
		FG4	0.817			
F	TTO efficiency	TTO1	0.723^{**}	0.449^{**}		1.38
		TTO2	0.863^{**}	0.730^{**}		2.05
		TTO3	0.480^{**}	0.292^{*}		1.27
		TTO4	0.481^{**}	0.056		1.81
		TTO5	0.358^{**}	-0.337^{*}		1.87
	Social capital	SC1	0.263^{**}	-0.216^{*}		1.30
		SC2	0.960^{**}	0.897^{**}		2.09
		SC3	0.625^{**}	0.016		1.96
		SC4	0.731^{**}	0.261^{*}		1.92
		SC5	0.580^{**}	-0.009		1.79

[a] Rows indicate AVE for reflective measures.

[b] Rows indicate weights for formative measures. Items SD1, EP4 and EP5 were deleted due to indicator's loading below the threshold values based on a consideration that the deletion led to an increase in composite reliability and average variance extracted [Hair *et al.* (2014)].

Notes: $^{*}p < 0.05$ ($t > 1.645$), $^{**}p < 0.01$ ($t > 2.33$).

The R^2 values were both above 0.35 indicating a substantial model [Cohen (1988)]. Six hypotheses (H1, H2, H4, H8, H9, and H10) were significant with β values ranging from 0.166 to 0.52 in expected directions. The six significant relationships also showed

Table 3. Discriminant validity of reflective measures.

Construct	SD	EP	FG	OR	RT	SM	AEP
SD	**0.857**						
EP	0.408	**0.943**					
FG	0.379	0.489	**0.832**				
OR	0.685	0.355	0.445	**0.925**			
RT	0.58	0.459	0.521	0.659	**0.866**		
SM	0.173	0.462	0.216	0.2	0.207	**0.881**	
AEP	0.668	0.453	0.568	0.671	0.58	0.174	**0.742**

Notes: SD: Self-regulated learning, EP: Entrepreneurial peers, FG: Funding, OR: Opportunity recognition, RT: Risk taking, SM: Mentor support, AEP: Academic entrepreneurship performance.

substantive effects with medium effect sizes (f^2). The predictive relevance (Q^2) of the model was estimated using the SmartPLS blindfolding function (omission distance setting, $D = 6$). The results showed that the Q^2 value was more than zero, suggesting that the exogenous constructs had a large predictive relevance for the endogenous constructs under consideration [Fornell and Cha (1994); Hair *et al.* (2014)].

The indirect hypothesized relationships were tested using the "boostrapping the indirect effect" method [Preacher and Hayes (2004, 2008)]. The results in Table 4 show that two indirect effects (H6 and H13) were significant. Their 95% bootstrapping confidence intervals, [LL = 0.052, UL = 0.226] and [LL = 0.014, UL = 0.134], did not straddle a "0", thus verifying that there was mediation. These results confirmed that scientists' self-regulated learning and social capital indirectly relate to academic entrepreneurship performance through their ability to identify the commercial opportunity of academic research.

Table 4. Results of structural model assessment.

No.	Relationship	β	Std.	t-value	R^2	f^2	Q^2	Hypothesis
H1	OR →AEP	0.293	0.088	3.338^{**}		0.105		Supported
H2	SC → OR	0.219	0.096	2.289^{*}		0.048		Supported
H3	SM → OR	0.064	0.053	1.197		0.008		Not supported
H4	SD →OR	0.52	0.097	5.363^{**}	0.5	0.273	0.420	Supported
H5	SD → AEP	0.123	0.083	1.49		0.017		Not supported
H7	RT → AEP	−0.064	0.059	1.082		0.005		Not supported
H8	SC → AEP	0.308	0.077	3.993^{**}		0.130		Supported
H9	TTO → AEP	0.202	0.084	2.397^{**}	0.674	0.065	0.345	Supported
H10	FG → AEP	0.166	0.078	2.113^{*}		0.048		Supported
H11	SM → AEP	−0.103	0.086	1.2		0.024		Not supported
H12	EP →AEP	0.071	0.065	1.091		0.009		Not supported
H6	[a]SD→OR→AEP	0.153	0.052	2.944*				Supported
H13	[b]SC→OR→AEP	0.064	0.038	1.699*				Supported

[a,b]indirect relationships.

Note: $^{*}p < 0.05$ ($t > 1.645$), $^{**}p < 0.01$ ($t > 2.33$).

SD: Self-regulated learning, EP: Entrepreneurial peers, SC: Social capital, FG: Funding, TTO: Technology Transfer Office, ORC: Opportunity recognition, RT: Risk taking, SM: Mentor support, AEP: Academic entrepreneurship performance.

Demographic characteristics such as gender [Koellinger (2008); Ramos-Rodriguez (2010); Tartari *et al.* (2014)] and academic post status [Kalar and Antoncic (2015); Tartari *et al.* (2014)] were tested as control variables. In SmartPLS, these control variables were treated as independent variables together with the other eight latent variables [Jabbour *et al.* (2015)]. The regression weights and their significances were then examined to test the effect of the control variables on the hypothesized relationships that were statistically significant before the post-hoc analysis (TTO → AEP, FG → AEP, SC → AEP, ORC → AEP). The results of the post-hoc analysis showed that these relationships remained statistically significant despite the inclusion of the control variables. Therefore, the effects of the control variables were ruled out.

5. Discussion

This study's main findings reveal that scientists' opportunity recognition ($\beta = 0.293$) and social capital ($\beta = 0.308$) are the strongest contributing factors to their academic entrepreneurship performance. TTO efficiency ($\beta = 0.202$) and ease of getting funding ($\beta = 0.166$) also play influential roles, albeit to a lesser extent. Contrary to expectations, this study did not find organisational culture to significantly improve scientists' engagement in academic entrepreneurship. Interestingly, the findings provide new evidence that scientists' self-regulated learning indirectly influences academic entrepreneurship performance by developing their opportunity recognition.

Consistent with Clarysse *et al.* [2011] and Ramos-Rodríguez *et al.* [2010], this study corroborates that scientists' academic entrepreneurship performance is strongly impacted by their opportunity recognition ability. Scientists with this ability can assume the role of academic entrepreneurs because they are good at perceiving unmet customer needs and unique value propositions offered by their research discoveries to the market [Chesbrough and Rosenbloom (2002)]. The measures of opportunity recognition in this study (see Appendix A) further suggest that a trait of academic entrepreneurs that differentiates them from their non entrepreneurial colleagues is the ability to identify the disruptive or sustaining technological potentials of their academic research. Scientists' higher opportunity recognition is reflected by their increased ability to identify research ideas and design new products or services that benefit other organizations, solve consumer problems, or improve existing products. The sustaining or disruptive characteristics of these technological discoveries [Kassicieh *et al.* (2002); Walsh *et al.* (2002)] raise the commercial value of academic research [Markman *et al.* (2008); Rasmussen *et al.* (2011)]. This study found weak support for the hypothesized positive relationship between scientists' self-regulated learning and their academic entrepreneurship performance, similar to Keith *et al.* [2016]. Nevertheless, this study empirically proves that scientists' self-regulated learning indirectly influences their academic entrepreneurship performance by developing their opportunity recognition. This finding is in line with the psychological perspective that asserts the influence of deliberate practice on reinforcing skills in a particular domain [Ericsson *et al.* (1993)]. Scientists' self-regulated learning is shown by their frequent deliberate activities in developing a commercialization plan; in attending seminars or conferences to gain more knowledge on other research ideas; in attending exhibitions to learn about commercialized products; in discussing problems that can potentially be resolved through research with contacts from the industry; in gathering market information about potential customers, suppliers, and competitors; in seeking potential investors; in sourcing business or industrial partners; and in consulting external agencies to refine and enhance their business plan. Through these self-regulated learning efforts, scientists are exposed to information and knowledge that allow them to become more creative and innovative in exploring opportunities to translate their research into marketable products or technology. Indeed, learning behavior plays a crucial role in developing entrepreneurial creativity [Rigolizzo and Amabile (2015)] and proactive learning efforts [Kickul and Walters (2002)] align well with Kuckertz *et al.* [2017] who found that entrepreneurs have higher chance to recognize opportunity as a result their active involvement in searching, being alert, gathering information, communicating, addressing customer needs and evaluating. These findings are consistent with those of Kaish and Gilad [1991], who attested that a characteristic of entrepreneurs is their frequent involvement in information seeking, through which entrepreneurial opportunities are discovered in a systematic search process. This is because scientists' frequent involvement in information seeking reinforces their cognitive resources, as conjectured in cognitive psychology and social cognition theory [Mitchell *et al.* (2002)], that enable them to assess, judge and decide the emerging opportunities [Neill *et al.* (2017)]. Scientist's self-regulated learning behavior introduced in this study could also be perceived as a form practical entrepreneurship education that has been proven to contribute to the academic entrepreneurship performance [Sansone *et al.* (2019)].

The results from the formative measurement model imply that scientists' personal network, consisting of their close family and friends, is the most important social resource for their academic entrepreneurship performance. The second most important social resource is their business partners and potential investors. These observations are consistent with earlier reports [Sequeira *et al.* (2007)] that a supportive and strong relationship with one's personal network engenders a stronger effect on entrepreneurial intention than non-affective contacts like business networks. A significant inverse relationship was found between scientists' professional network and their academic entrepreneurship performance, which is in accordance with Fernández-Pérez *et al.* [2015] but in contrast with Aldridge and Audretsch [2011]. Academic scientists are likely to gain many professional contacts through their attendance at conferences, workshops and seminars; however, these knowledge-sharing platforms often revolve around scientific knowledge rather than academic entrepreneurship.

Consistent with earlier studies [Fernández-Pérez *et al.* (2015); Ramos-Rodríguez *et al.* (2010)], the results support the indirect relationship between scientists' social capital and academic entrepreneurship performance by way of their opportunity recognition. Furthermore, this study discovers that the influence of scientists' self-regulated learning behavior in enhancing their opportunity recognition ability is far greater than the influence of social capital. Since scientists' social capital is mostly built on a personal network that provides emotional support, the role of scientists' self-regulated learning behavior exceeds that of social capital by enabling scientists to gain more access to external knowledge that helps them better recognize entrepreneurial opportunity.

In line with Clarysse *et al.* [2011], institutional support through TTO plays a weaker role than personal factors in improving scientists' academic entrepreneurship performance. The results from the formative measurement model, which are partly discussed in Rahim *et al.* [2019], grant new insights into TTO services by highlighting that facilitating patent application and technology licensing is its most important role. The second most important role of a TTO is to organize programs to increase scientists' understanding of the technology transfer process. In accordance with Slavtchev and Göktepe-Hultén [2015], the findings also suggest that the TTO's third most vital role is to aid scientists' financial planning. However, contrary to Aldridge and Audretsch (2011), it is intriguing to discover a significant inverse relationship between the efficiency of TTO employees and scientists' technology transfer pursuit. This observation is partly due to the relatively new establishment of the TTO in UTM (TTO age < 10 years) compared to the average age of those in developed countries (United States: 18.5 years; United Kingdom: 17.5 years; Spain: 18 years; Denmark: 13 years) [Rizzo and Ramaciotti (2014)].

The ease of getting funding shows the weakest influence on scientists' academic entrepreneurship performance. The Malaysian government steadily increased the amount of funding between the year 2000 and the year 2012 [MASTIC (2016)]. However, several qualitative studies suggest that the low entrepreneurial activity rate among Malaysian scientists is caused by a lack of financial support [Khademi *et al.* (2015)]. This study provides evidence from a new perspective, indicating that instead of the funding amount, the difficulty scientists face in the process of applying for and obtaining funds deters them from participating in technology transfer and research commercialization activities.

Unexpectedly, neither mentor support nor the presence of entrepreneurial peers among colleagues were found to significantly improve academic entrepreneurship performance. Contradictory to previous studies [Fernández-Pérez *et al.* (2015); St-Jean and Audet (2012); Tartari *et al.* (2014)], the reason for this insignificant result is because entrepreneurial culture in a university is a rather intangible element [Bradley *et al.* (2013)]. The hypothesized relationships, therefore, may only hold in a certain population of scientists under a particular context. The cultural revolution towards an entrepreneurial society in the United States took root in the early 1960s, when the entrepreneurial mindset to create new values, new products, and new industries was instilled and passed down through generations [Audretsch (2007)]. In contrast, the sample in this study was drawn from a population of scientists from UTM who relative novices in academic entrepreneurship.

Regarding scientists' risk-taking propensity, though the regression coefficient showed a negative value, there was insufficient evidence to verify the significance of its impact on scientists' academic entrepreneurship performance. The potential reason behind this finding's refutation of earlier studies [Fernández-Pérez *et al.* (2015); Guerrero *et al.* (2008); Kirkman (2013)] could be the cultural difference across countries. For instance, the relative lack of entrepreneurial activity in Japan [Fukao and Kwon (2011)] has been attributed to Japanese culture that accentuates conventionality and consistency in a way that discourages risk-taking behavior, which is the opposite of American culture [Kagami (2015)]. Accordingly, this study implies a mindset in UTM that ascribes a mixed level of appreciation towards academic entrepreneurship, which explains the insignificant influence of culture on scientists' academic entrepreneurship performance.

6. Implications, Limitations, and Future Research

Research on the antecedents of opportunity recognition has paid less attention to intentional systematic search or the discovery of an opportunity by deliberately searching for it [Fiet *et al.* (2005); George *et al.* (2014)]. This study expands the literature by building upon the concept of deliberate practice [Ericsson *et al.* (1993)] and the operationalization of this construct in the academic entrepreneurship context [Keith *et al.* (2016)]. Eight indicators were developed in this study to measure scientists' self-regulated entrepreneurial learning. The results augment the limited evidence on how autonomous deliberate effort in entrepreneurial learning positively influences opportunity recognition, which further explains improved academic entrepreneurship performance. The results provide a basis for aspiring academic entrepreneurs among scientists on how they could self-develop their entrepreneurial ability. Scientists should position themselves strategically in their environment and manage their knowledge acquisition through deliberate practice. This finding emphasizes the importance of entrepreneur's self-regulatory capability and the underlying mechanism that make some scientists increasingly better at recognizing opportunity while others unable to develop such capability.

The outcomes of this research provide practical implications for the authorities to spur academic entrepreneurship among scientists. Universities should inculcate science and engineering students with an entrepreneurial mindset and entrepreneurial abilities as they are the closest candidates to potentially be groomed into academic entrepreneurs [Morales-Alonso *et al.* (2016); Philpott *et al.* (2011); Reguera (2016); Zhang *et al.* (2014)]. Integrating an entrepreneurship training module that encourages students to assess unique value propositions of technology start-ups would expose them to how entrepreneurs align important problems with feasible technological solutions and viable businesses, which in turn would develop students' opportunity recognition. Moreover, the indicators of academic entrepreneurs' self-regulated learning efforts are useful to universities' engineering faculty to promote deliberate practices among scientists to advance their opportunity recognition. As seminars about intellectual property and patenting procedures are already widely held, universities' engineering faculty should focus more on raising awareness about opportunity creation and recognition from academic research. The findings of weak relationship between risk taking propensity and academic entrepreneurship performance imply that university should focus on developing a positive attitude and strengthen entrepreneurial skills among scientists to rethink about commercial challenge and be less risk averse. Entrepreneurial proactive behavior among scientists to gather external information that exposes them to more ideas and opportunities should be encouraged that will further enhance academic entrepreneurship performance.

The findings of this study are limited to the case study population of UTM; thus, they are not generalizable to other contexts. Future studies should extend the proposed research model to broader geographical scopes and populations. This study suggests two avenues for future research. First, future studies may explore the extent to which academic entrepreneurs discover opportunity by chance during R&D or by strategic plans to create opportunity from the onset of academic research. New findings that distinguish between opportunity discovery and opportunity creation would be valuable for theoretical advancement in the academic entrepreneurship literature. For instance, researchers may consider a longitudinal setting to investigate how tacit knowledge developed from experience and prior education allows academic scientists to discover or create entrepreneurial opportunities from academic research. Longitudinal research is also recommended to eliminate the possibility of reverse causality since this study is based on cross-sectional data. Second, future studies can build upon the operationalization of academic entrepreneurs' self- regulated learning behavior in this study to explore the possible moderating effect of entrepreneurial alertness [George *et al.* (2014); Kirzner (1979)] in strengthening opportunity recognition.

Appendix A

Table A.1. Survey instrument comprising measurement items for all the variables

Variable	Item	Source
Academic entrepreneurship performance (AEP)	AEP1—Applied patent (patent filing) for my research findings. AEP2—Registered patent (patent granted) for my research findings. AEP3—Licensed to other organization my research findings for them to develop and sell product. AEP4—Developed potential prototype, technology and process which can be commercialized to the industry. AEP5—Developed *solutions that can enhance the product of other industry. *technology or know-how(ideas) that could stand alone/used with other technologies AEP6—Created spin-off companies to commercialize research products	Adapted from Prodan and Drnovsek [2010], D'Este *et al.* [2012]
Self-regulated learning (SD)	SD1—Develop commercialization plan for my research findings. SD2—Attended seminar and onferences to gain more knowledge on other research ideas SD3—Attended exhibition to gain more knowledge on products that has been commercialized SD4—Discuss with contacts from the industry on their problems that potentially being resolved through research. SD5—Gather market information about potential customer, supplier or competitor	Adapted from Macnamara *et al.* [2014], Keith *et al.* [2016]

Table A.1. (*Continued*)

Variable	Item	Source
	SD6—Seek potential investor who is interested to fund the commercialization of my research findings. SD7—Seek business or industrial partner who is interested to commercialize my research findings. SD8—Consult external support such as TTO or external agencies to refine and enhance business plan.	
Opportunity recognition (OR)	OR1—Identify *research ideas* that can be converted into new product or services (even though I may not pursue them). OR2—Identify research ideas that can improve existing product or services (even though I may not pursue them) OR3—Identify research ideas that can benefit other organizations (even though I may not pursue them) OR4—Design product or services to improve consumer problems (even though I may not pursue them)	Adapted from Clarysse *et al.* [2011]
Risk taking (RT)	RT1—I am capable to work productively under pressure and stressful condition. RT2—I am persistent in achieving my mission even though facing with adversity. RT3—If I identified commercial application of my research, I would seriously consider putting more effort to commercialize the opportunity.	Adapted from Fernández-Pérez *et al.* [2015]
Technology Transfer Office (TTO)	TTO1—I think that programs organized by TTO increase my understanding about the process of commercializing research findings. TTO2—I think that the *commercialization services provided by TTO has assisted me to commercialize research findings. (*prototype development, patent application, technology licensing/assignment) TTO3—I think that the services provided by TTO has assisted me to develop *financial planning to commercialize research findings. (*business plan, market validation) TTO4—I think that the *services provided by TTO has assisted me to secure partners to commercialize research findings. (* marketing, promotion, exhibition) TTO5—I think that the TTO personnel are efficient in assisting me to commercialize research findings.	
Social capital (SC)	SC1—My contacts from professional forums* have been facilitating me with information and support that encourage me to commercialize my research findings. *professional forums: Conferences/Workshop/Seminars SC2—My contacts from personal network have been facilitating me with information and support that encourage me to commercialize my research findings. *personal network: Friends/Close Family/Colleagues SC3—My contacts or discussion with potential customers or potential suppliers has been facilitating me with information and support that encourage me to commercialize my research findings. SC4—My contacts or discussion with new partners or potential investors has been facilitating me with	Adapted from Fernández-Pérez *et al.* [2015]

Table A.1. (*Continued*)

Variable	Item	Source
	information and support that encourage me to commercialize my research findings. SC5—My contacts or discussion with potential competitors has been facilitating me with information and support that encourage me to commercialize my research findings.	
Funding (FG)	FG1—I think that the grant offered for *research and development activities is easily obtainable. (*Value analysis, concept idea, basic R&D, applied R&D) FG2—I think that the grant offered for *pre-commercialization activities is easily obtainable. (* Experimental Research Prototype, Incubation) FG3—I think that the grant offered for *commercialization activities is easily obtainable. (* Pilot production, Early Growth, Mature Production, Value Realization) FG4—Various grants that are easily obtained encourage me to pursue effort to commercialize research findings (*grants for R&D, pre-commercialization and commercialization)	
Entrepreneurial peers (EP)	EP1—A colleague who has been involved in *transfer of knowledge activities inspires me to get involved in the same activity too. (* book writing/consultation/contract research) EP2—A colleague who has been involved in *transfer of technology activities inspires me to get involved in the same activity too. (* licensing/patenting) EP3—A colleague who has been involved in *transfer of product activities inspires me to get involved in the same activity too. (* creation of spin-offs) EP4—A colleague who has been involved in *pre-commercialization activities inspires me to get involved in the same activity too. (* Experimental Research Prototype/Incubation) EP5—A colleague who has been involved in *commercialization activities inspires me to get involved in the same activity too. (* Pilot production/Early Growth, Mature Production/Value Realization)	Adapted from Huyghe and Knockaert [2015]
Mentor support (SM)	SM1—I have a mentor who has been facilitating me to identify ideas on how my research can be exploited for commercialization. SM2—I have a mentor who has been facilitating me with information and support to undertake *pre-commercialization activities. (*Experimental Research Prototype/Incubation) SM3—I have a mentor a mentor who has been facilitating me with information and support to undertake *commercialization activities. (*Pilot production/Early Growth/Mature Production/Value Realization) SM4—I have a mentor who has been facilitating me with information and support to get involved in book writing or consultation or contract research activities.	Adapted from Fernández-Pérez *et al.* [2015]

Table A.1. (*Continued*)

Variable	Item	Source
	SM5—I have a mentor who has been facilitating me with information and support to get involved in licensing and patenting. SM6—I have a mentor who has been facilitating me with information and support to get involved in creation of spin-offs	

Acknowledgments

This paper draws on support from Research University Grant Tier 2, awarded by Universiti Teknologi Malaysia for a research project entitled ‘Connecting Academic Entrepreneurs’ Self-Directed Learning to their Entrepreneurial Performance’ (Q.K130000.2656.17J26).

References

Ajzen, I. (1991). The theory of planned behaviour. *Organizational Behavior and Human Decision Processes*, **50**, 2: 179–211.

Aldridge, T. T. and Audretsch, D. (2011). The Bayh-Dole Act and scientist entrepreneurship. *Research Policy*, **40**, 8: 1058–1067.

Alvarez, S. A. and Barney, J. B. (2007). Discovery and creation: alternative theories of entrepreneurial Action. *Strategic Entrepreneurship Journal*, **1**, 2: 11–26.

Andreev, P., Heart, T., Maoz, H. and Pliskin, N. (2009). Validating formative partial least squares (PLS) models: Methodological review and empirical illustration. In *ICIS 2009 Proceedings*, Phoenix, Arizona, USA, p. 193.

Anderson, J. C. and Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, **103**, 3: 411.

Audretsch, D. B. (2007). *The Entrepreneurial Society*. Oxford University Press, Oxford.

Audretsch, D. B., Lehmann, E. E. and Paleari, S. (2015). Academic policy and entrepreneurship: A European perspective. *The Journal of Technology Transfer*, **40**, 3: 363–368.

Baron, R. A. and Markman, G. D. (2000). Beyond social capital: How social skills can enhance entrepreneurs’ success. *The Academy of Management Executive*, **14**, 1: 106–116.

Barth, T. D. and Schlegelmilch, W. (2013). Academic entrepreneur, academic entrepreneurship. *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*, ed. O. Torre. Springer, New York, pp. 1–8.

Bercovitz, J. and Feldman, M. (2008). Academic entrepreneurs: Organizational change at the individual level. *Organization Science*, **19**, 1: 69–89.

Bello, B., Mattana, V. and Loi, M. (2018). The power of peers: A new look at the impact of creativity, social context and self-efficacy on entrepreneurial intentions. *International Journal of Entrepreneurial Behavior & Research*, **24**, 1: 214– 233.

Bradley, S. R., Hayter, C. S. and Link, A. (2013). Models and methods of university technology transfer. *Foundations and Trends in Entrepreneurship*, **9**, 6.

Brockhaus, R. H. (1980). Risk taking propensity of entrepreneurs. *Academy of Management Journal*, **23**, 3: 509–520.

Brookfield, S. D. (2009). Self-directed learning. *International Handbook of Education for the Changing World of Work*, ed. R. Maclean and D. Wilson. Springer, Netherland, pp. 2615–2627.

Campbell, D. T. and Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, **56**, 2: 81.

Casson, M. (2005). The individual–opportunity nexus: A review of Scott Shane: A general theory of entrepreneurship. *Small Business Economics*, **24**, 5: 423–430.

Cenfetelli, R. T. and Bassellier, G. (2009). Interpretation of formative measurement in information systems research. *MIS Quarterly*, **33**: 689–707.

Chell, E. (2013). Review of skill and the entrepreneurial process. *International Journal of Entrepreneurial Behavior & Research*, **19**, 1: 6–31.

Chell, E., Haworth, J. M. and Brearley, S. A. (1991). *The Entrepreneurial Personality: Concepts, Cases and Categories*. Routledge, London.

Chesbrough, H. and Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: Evidence from xerox corporation's technology spin-off companies. *Industrial and Corporate Change*, **11**, 3: 529–555.

Clarysse, B., Tartari, V. and Salter, A. (2011). The impact of entrepreneurial capacity, experience and organizational support on academic entrepreneurship. *Research Policy*, **40**, 8: 1084–1093.

Closs, L., Ferreira, G., Brasil, V., Sampaio, C. and Perin, M. (2013). What motivates brazilian academic researchers to transfer technology?*Journal of Technology Management and Innovation*, **8**, 4: 79–90.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Lawrence Erlbaum Assoc, London.

Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative and Mixed Method Approaches*, 2nd edn.. Sage Publications, California.

Cromie, S. (2000). Assessing entrepreneurial inclinations: Some approaches and empirical evidence. *European Journal of Work and Organizational Psychology*, **9**, 1: 7–30.

Dawson, C. (2002). *Practical Research Methods: A User-Friendly Guide to Mastering Research*. Cromwell Press, Oxford.

D'Este, P., Mahdi, S., Neely, A. and Rentocchini, F. (2012). Inventors and entrepreneurs in academia: What types of skills and experience matter?*Technovation*, **32**, 5: 293–303.

Di Gregorio, D. and Shane, S. (2003). Why do some universities generate more start-ups than others? *Research Policy*, **32**, 2: 209–227.

Ericsson, K. A., Krampe, R. T. and Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, **100**, 3: 363.

Etzkowitz, H. (2016). The entrepreneurial university: Vision and metrics. *Industry and Higher Education*, **30**, 2: 83–97.

Faul, F., Erdfelder, E., Buchner, A. and Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, **41**, 4: 1149–1160.

Feldmann, B. (2014). Dissonance in the academy: The formation of the faculty entrepreneur. *International Journal of Entrepreneurial Behavior & Research*, **20**, 5: 453–477.

Fernández-Pérez, V., Alonso-Galicia, P. E., Rodríquez-Ariza, L. and del Mar Fuentes-Fuentes, M. (2015). Professional and personal social networks: A bridge to entrepreneurship for academics?*European Management Journal*, **3**, 1: 37–47.

Fiet, J. O., Piskounov, A. and Patel, P. C. (2005). Still searching (systematically) for entrepreneurial discoveries. *Small Business Economics*, **25**, 5: 489–504.

Fust, A. P., Jenert, T. and Winkler, C. (2017). Experiential or self-regulated learning: A critical reflection of entrepreneurial learning processes. *Entrepreneurship Research Journal*, **8**, 2: 20170098.

Fornell, C. and Cha, J. (1994). Partial least squares. *Advanced Methods in Marketing Research*. ed. R. P.Bagozzi. Blackwell, Cambridge, pp. 52–78.

Fornell, C. and Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. Graduate School of Business Administration, Univeirisity of Michigan.

Franklin, S. J., Wright, M. and Lockett, A. (2001). Academic and surrogate entrepreneurs university spin-out companies. *The Journal of Technology Transfer*, **26**, 1–2: 127–141.

Fuentes, M. D. M. F., Arroyo, M. R., Bojica, A. M. and Pérez, V. F. (2010). Prior knowledge and social networks in the exploitation of entrepreneurial opportunities. *International Entrepreneurship and Management Journal*, **6**, 4: 481–501.

Fukao, K. and Kwon, H. U. (2011). Sources of future economic growth in japan: An empirical analysis based on micro- data. RIETI Discussion Paper Series, No. 11-J-045.

Gefen, D., Straub, D. W. and Rigdon, E. E. (2011). An update and extension to sem guidelines for administrative and social science research. *Management Information Systems Quarterly*, **35**, 2: 3–14.

Geisler, E. and Turchetti, G. (2015). Commercialization of technological innovations: The effects of internal entrepreneurs and managerial and cultural factors on public–private inter-organizational cooperation. *International Journal of Innovation and Technology Management*, **12**, 2.

George, N. M., Parida, V., Lahti, T. and Wincent, J. (2014). A systematic literature review of entrepreneurial opportunity recognition: Insights on influencing factors. *International Entrepreneurship and Management Journal*, **1**, 42.

Gibb, A. and Hannon, P. (2006). Towards the entrepreneurial university. *International Journal of Entrepreneurship Education*, **4**, 1: 73–110.

Global Entrepreneurship Monitor, GEM (2020). *Malaysia Entrepreneurial Framework Conditions*. https://www.gemconsortium.org/economy-profiles/malaysia-86 [accessed on 8 July 2020].

Goethner, M., Obschonka, M., Silbereisen, R. K. and Cantner, U. (2011). Foundations of academic entrepreneurship: A path model for the prediction of scientists' academic entrepreneurial intentions. In *DIME Final Conference*, 6–8 April, IEEE, Maastricht, the Netherlands.

Gregorio, D., D. and Shane, S. (2003). Why do some universities generate more start-ups than others? *Research Policy*, **32**, 2: 209–227.

Greve, A. (1995). Networks and entrepreneurship: An analysis of social relations, occupational background and use of contacts during the establishment process. *Scandinavian Journal of Management*, **11**, 1: 1–24.

Grimaldi, R., Kenney, M., Siegel, D. S. and Wright, M. (2011). 30 years after Bayh-Dole: Reassessing academic entrepreneurship. *Research Policy*, **40**, 8: 1045–1057.

Gubitta, P., Tognazzo, A. and Destro, F. (2016). Signaling in academic ventures: The role of technology transfer offices and university funds. *The Journal of Technology Transfer*, **41**, 2: 368–393.

Guerrero, M., Cunningham, J. A. and Urbano, D. (2015). Economic impact of entrepreneurial universities' activities: An exploratory study of the United Kingdom. *Research Policy*, **44**, 3: 748–764.

Guerrero, M., Rialp, J. and Urbano, D. (2008). The impact of desirability and feasibility on entrepreneurial intentions: A structural equation model. *International Entrepreneurship and Management Journal*, **4**, 1: 35–50.

Guerrero, M. and Urbano, D. (2012). The development of an entrepreneurial university. *The Journal of Technology Transfer*, **37**, 1: 43–74.

Guerrero, M. and 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.

Hair, J. F., Hult, G. T. M., Ringle, C. and Sarstedt, M. (2014). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. Sage Publications, London.

Hajizadeh, A. and Zali, M. (2016). Prior knowledge, cognitive characteristics and opportunity recognition. *International Journal of Entrepreneurial Behavior & Research*, **22**, 1: 63–83.

Hanohov, R. and Baldacchino, L. (2018). Opportunity recognition in sustainable entrepreneurship: An exploratory study. *International Journal of Entrepreneurial Behavior & Research*, **24**, 2: 333–358.

Huyghe, A. and Knockaert, M. (2015). The influence of organizational culture and climate on entrepreneurial intentions among research scientists. *The Journal of Technology Transfer*, **40**, 1: 138–160.

Iacobucci, D. and Micozzi, A. (2015). How to evaluate the impact of academic spin-offs on local development: An empirical analysis of the Italian Case. *The Journal of Technology Transfer*, **40**, 3: 434–452.

Jabbour, C. J. C., Jugend, D., de Sousa Jabbour, A. B. L., Gunasekaran, A. and Latan, H. (2015). Green product development and performance of Brazilian firms: Measuring the role of human and technical aspects. *Journal of Cleaner Production*, **87**, 442–451.

Jain, S., George, G. and Maltarich, M. (2009). Academics or entrepreneurs? investigating role identity modification of university scientist involved in commercialization activity. *Research Policy*, **38**, 6: 922–935.

Jensen, R. and Thursby, M. (2003). The disclosure and licensing of university inventions: The best we can do with the s**t we get to work with. *International Journal of Industrial Economics*, **21**, 9: 1271–1300.

Kagami, S. (2015). Innovation and university entrepreneurship: Challenges facing Japan Today. ed. *Innovation, Technology Transfers, Finance, and Internationalization of SMEs' Trade and Investment*, eds. S. P. Oum, G. Intarakumnerd Abonyi and S. Kagami. ERIA Research Project Report (No.14), ERIA, Jakarta, pp. 97–121.

Kaish, S. and Gilad, B. (1991). Characteristics of Opportunities Search of Entrepreneurs versus Executives: Sources, Interests, General Alertness. *Journal of Business Venturing*, **6**, 1: 45–61.

Kalar, B. and Antoncic, B. (2015). Social capital of academics and their engagement in technology and knowledge transfer. *Science and Public Policy*, **42**, 6.

Karlsson, T. and Wigren, C. (2012). Start-ups among university employees: The influence of legitimacy, human capital and social capital. *The Journal of Technology Transfer*, **37**, 3: 297–312.

Kassicieh, S. K., Kirchhoff, B. A., Walsh, S. T. and McWhorter, P. J. (2002). The role of small firms in the transfer of disruptive technologies. *Technovation*, **22**, 11: 667–674.

Keith, N., Unger, J. M., Rauch, A. and Frese, M. (2016). Informal learning and entrepreneurial success: A longitudinal study of deliberate practice among small business owners. *Applied Psychology: An International Review*, **65**, 3: 515–540.

Khademi, T., Ismail, K., Lee, C. T. and Shafaghat, A. (2015). enhancing commercialization level of academic research outputs in research university. *Jurnal Teknologi*, **74**, 4.

Kickul, J. and Walters, J. (2002). Recognizing new opportunities and innovations: The role of strategic orientation and proactivity in internet firms. *International Journal of Entrepreneurial Behavior & Research*, **8**, 6: 292–308.

Kirchberger, M. A. and Pohl, L. (2016). Technology commercialization: A literature review of success factors and antecedents across different contexts. *The Journal of Technology Transfer*, **41**, 5: 1077–1112.

Kirkman, D. M. (2013). Survival and growth motivations as predictors of university-biotechnology technology transfer activities. *Journal of Entrepreneurship Education*, **16**, 33.

Kirzner, I. M. (Ed.) (1979). *Perception, Opportunity and Profit*. University of Chicago Press, Chicago.

Kochenkova, A., Grimaldi, R., & Munari, F. (2016). Public Policy measures in support of knowledge transfer activities: A review of academic literature. *The Journal of Technology Transfer*, **41**, 3: 407–429.

Koellinger, P. (2008). Why are some entrepreneurs more innovative than others? *Small Business Economics*, **31**, 1: 21.

Kuckertz, A., Kollmann, T., Krell, P. and Stöckmann, C. (2017). Understanding, differentiating and measuring opportunity recognition and opportunity exploitation. *International Journal of Entrepreneurial Behavior & Research*, **23**, 1: 78–97.

Landry, R., Amara, N. and Rherrad, I. (2006). Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian Universities. *Research Policy*, **35**, 10: 1599–1615.

Loch, K. D., Straub, D. W. and Kamel, S. (2003). Diffusing the internet in the Arab world: The role of social norms and technological culturation. *IEEE Transactions on Engineering Management*, **50**, 1: 45–63.

Lowry, P. B. and Gaskin, J. (2014). Partial least squares (PLS) structural equation modeling (SEM) for building and testing behavioral causal theory: When to choose it and how to use it. *IEEE Transactions on Professional Communication*, **57**, 2: 123–146.

Macnamara, B. N., Hambrick, D. Z. and Oswald, F. L. (2014). Deliberate practice and performance in music, games, sports, education, and professions: A meta-analysis. *Psychological Science*, **25**, 8: 1608–1618.

Malaysian Science and Technology Information Centre MASTIC (2013). *National Research and Development Studies.* MOSTI, Putrajaya: http://www.mastic.gov.my/[accessed on 15 December 2015].

Malaysian Science and Technology Information Centre MASTIC (2013b). Science and Technology Inventory, TECHMart. Putrajaya: MOSTI. Retrieved January 10, 2016 from http://www.mastic.gov.my/.

Malaysian Science and Technology Information Centre MASTIC (2015b). STI Human Resources. Putrajaya: MOSTI. Retrieved Dec 15, 2015 from http://www.mastic.gov.my/.

Markman, G., Phan, P., Balkin, D. and Gianiodis, P. (2005). Entrepreneurship and university-based technology transfer. *Journal of Business Venturing*, **20**, 2: 241–263.

Markman, G. D., Siegel, D. S. and Wright, M. (2008). Research and technology commercialization. *Journal of Management Studies*, **45**, 8: 1401–1423.

Markuerkiaga, L., Igartua, J. I. and Errasti, N. (2014). Factors fostering entrepreneurial universities to develop academic entrepreneurship activities: An assessment of European universities. *International Journal of Technology Transfer and Commercialisation*, **13**, 1–2: 107–132.

Mitchell, R. K., Busenitz, L., Lant, T., McDougall, P. P., Morse, E. A. and Smith, J. B. (2002). Toward a theory of entrepreneurial cognition: Rethinking the people side of entrepreneurship research. *Entrepreneurship Theory and Practice*, **27**, 2: 93–104.

Mom, T. J., Oshri, I. and Volberda, H. W. (2012). The skills base of technology transfer professionals. *Technology Analysis & Strategic Management*, **24**, 9: 871–891.

Morales-Alonso, G., Pablo-Lerchundi, I. and Vargas-Perez, A. M. (2016). An empirical study on the antecedents of knowledge intensive entrepreneurship. *International Journal of Innovation and Technology Management*, **13**, 5: 1640011.

Muscio, A., Quaglione, D. and Ramaciotti, L. (2016). The effects of university rules on spinoff creation: The case of Academia in Italy. *Research Policy*, **45**, 7: 1386–1396.

Nanda, R. and Sørensen, J. B. (2010). Workplace peers and entrepreneurship. *Management Science*, **56**, 7: 1116–1126.

Neill, S., Metcalf, L. E. and York, J. L. (2017). Distinguishing entrepreneurial approaches to opportunity perception. *International Journal of Entrepreneurial Behavior & Research*, **23**, 2: 296–316.

Nielsen, K. (2015). Human capital and new venture performance: The industry choice and performance of academic entrepreneurs. *The Journal of Technology Transfer*, **40**, 3: 453–474.

Nosella, A. and Grimaldi, R. (2009). University–level mechanisms supporting the creation of new companies: An analysis of italian academic spin-offs. *Technology Analysis & Strategic Management*, **21**, 6: 679–698.

O'shea, R. P., Allen, T. J., Chevalier, A. and Roche, F. (2005). Entrepreneurial orientation, technology transfer and spinoff performance of US universities. *Research Policy*, **34**, 7: 994–1009.

Osiri, J. K., McCarty, M. M. and Jessup, L. (2013). Entrepreneurial culture in institutions of higher education: Impact on academic entrepreneurship. *Journal of Entrepreneurship Education*, **16**, 1.

Ozgen, E. and Baron, R. A. (2007). Social sources of information in opportunity recognition: Effects of mentors, industry networks, and professional forums. *Journal of Business Venturing*, **22**, 2: 174–192.

Pattnaik, P. N. and Pandey, S. C. (2016). Revisiting university spinoffs: Conceptual advancements and theoretical underpinnings. *International Journal of Innovation and Technology Management*, **13**, 1: 1650005.

Petkewich, R. (2009). Entrepreneurs in academic. *Chemical & Engineering News*, **87**, 16: 28–30.

Petter, S., Straub, D. and Rai, A. (2007). Specification and validation of formative constructs in IS research. *MIS Quarterly*, **31**, 4: 623–656.

Phan, P. H., Siegel, D. S. and Wright, M. (2005). Science parks and incubators: Observations, synthesis and future research. *Journal of Business Venturing*, **20**, 2: 165–182.

Philpott, K., Dooley, L., O'Reilly, C. and Lupton, G. (2011). The entrepreneurial university: Examining the underlying academic tensions. *Technovation*, **31**, 4: 161–170.

Pugalia, S., Sai, L. P. and Cetindamar, D. K. (2020). Personal networks' influence on student entrepreneurs: A qualitative study. *International Journal of Innovation and Technology Management*, **17**, 5: 1–23.

Podsakoff, P. M. and Organ, D. W. (1986). Self-reports in organizational research: Problems and prospects. *Journal of Management*, **12**, 4: 531–544.

Preacher, K. J. and Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods*, **36**, 4: 717–731.

Preacher, K. J. and Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, **40**, 3: 879–891.

Prodan, I. and Drnovsek, M. (2010). Conceptualizing academic-entrepreneurial intentions: An empirical test. *Technovation*, **30**, 5–6: 332–347.

Rahim, N. A., Mohamed, Z. B. and Amrin, A. (2015). Commercialization of emerging technology: The role of academic entrepreneur. *Procedia — Social and Behavioral Sciences*, **169**, 53–60.

Rahim, N. A., Mohamed, Z. B., Amrin, A., Masrom, M. and Shariff, S. A. (2019). Conceptualization and measurement of university technology transfer office efficiency as a formative construct. *International Journal of Engineering and Advanced Technology*, **8**, 5c: 191–197.

Ramos-Rodriguez, A., Medina-Garrido, J., Lorenzo-Gómez, J. and Ruiz-Navarro, J. (2010). What you know or who you know? The role of intellectual and social capital in opportunity recognition. *International Small Business Journal*, **28**, 6: 566–582.

Rao, B. and Mulloth, B. (2017). The role of universities in encouraging growth of technology-based new ventures. *International Journal of Innovation and Technology Management*, **14**, 4: 1750014.

Rasmussen, E., Moen, Ø. and Gulbrandsen, M. (2006). Initiatives to promote commercialization of university knowledge. *Technovation*, **26**, 4: 518–533.

Rasmussen, E. and Rice, M. P. (2011). A framework for government support mechanisms aimed at enhancing university technology transfer: The norwegian case. *International Journal of Technology Transfer and Commercialisation*, **11**, 1–2: 1–25.

Rasmussen, E., Mosey, S. and Wright, M. (2011). The evolution of entrepreneurial competencies: A longitudinal study of university spin-off venture emergence. *Journal of Management Studies*, **48**, 6: 1314–1345.

Rasmussen, E. and Sørheim, R. (2012). How governments seek to bridge the financing gap for university spin-offs: Proof- of-concept, pre-seed and seed funding. *Technology Analysis & Strategic Management*, **24**, 7: 663–678.

Rasmussen, E. and Wright, M. (2015). How can universities facilitate academic spin-offs? An entrepreneurial competency perspective. *The Journal of Technology Transfer*, **40**, 5: 782–799.

Reguera, G. (2016). Leaving the comfort zone: The path to academic entrepreneurship. *2016 SIMB Annual Meeting and Exhibition*. Society for Industrial Microbiology and Biotechnology, Virginia.

Renzulli, L. A., Aldrich, H. and Moody, J. (2000). Family matters: Gender, networks and entrepreneurial outcomes. *Social Forces*, **79**, 2: 523–546.

Reynolds, P. D., Carter, N. M., Gartner, W. B. and Greene, P. G. (2004). The prevalence of nascent entrepreneurs in the United States: Evidence from the panel study of entrepreneurial dynamics. *Small Business Economics*, **23**, 4: 263–284.

Richter, N. F., Cepeda, G., Roldán, J. L. and Ringle, C. M. (2015). European management research using partial least squares structural equation modeling (PLS-SEM). *European Management Journal*, **33**, 1: 1–3.

Rigolizzo, M. and Amabile, T. (2015). Entrepreneurial creativity: The role of learning processes and work environment supports. *The Oxford Handbook of Creativity, Innovation and Entrepreneurship*, Oxford University Press, United States, pp. 61–78.

Ringle, C. M., Wende, S. and Becker, J.M. (2015). SmartPLS 3. Hamburg: SmartPLS. http://www.smartpls.com [accessed on 23 Jan 2015]

Rizzo, U. and Ramaciotti, L. (2014). The determinants of academic patenting by italian universities. *Technology Analysis & Strategic Management*, **26**, 4: 469–483.

Roland, X., Noorseha, A., Leilanie, M. N. and Mohar, Y. (2011). Entrepreneurship in Malaysia. *Global Entrepreneurship Monitor Malaysian Report*. Global Entrepreneurship Research Association, London.

Sansone, G., Battaglia, D., Landoni, P. and Paolucci, E. (2019). Academic spinoffs: The role of entrepreneurship education. *International Entrepreneurship and Management Journal*, **17**, 1:369–399.

Santos, S. C., Caetano, A., Baron, R. and Curral, L. (2015). Prototype models of opportunity recognition and the decision to launch a new venture. *International Journal of Entrepreneurial Behavior & Research*, **21**, 4: 510–538.

Sanz-Velasco, S. A. (2006). Opportunity development as a learning process for entrepreneurs. *International Journal of Entrepreneurial Behavior & Research*, **12**, 5: 251–271.

Sarstedt, M., Ringle, C. M., Smith, D., Reams, R. and Hair, J. F. (2014). Partial least squares structural equation modeling (PLS-SEM): A useful tool for family business researchers. *Journal of Family Business Strategy*, **5**, 1: 105–115.

Schlepphorst, S., Koetter, E. C., Werner, A., Soost, C. and Moog, P. (2020). International assignments of employees and entrepreneurial intentions: The mediating role of human capital, social capital and career prospects. *International Journal of Entrepreneurial Behavior & Research*, **26**, 6: 1259–1279.

Sequeira, J., Mueller, S. L. and McGee, J. E. (2007). The Influence of social ties and self-efficacy in forming entrepreneurial intentions and motivating nascent behavior. *Journal of Developmental Entrepreneurship*, **12**, 3: 275–293.

Shane, S. and Venkataraman, S. (2000). The promise of entrepreneurship as a field of research. *Academy of Management Review*, **25**, 217–226.

Siegel, D. and Wright, M. (2015). Academic entrepreneurship: Time for a rethink? *British Journal of Management*, **26**, 4: 582–595.

Singer, S., Amorós, J. E., Arreeola, D. M. (2015). 2014 global report. *Global Entrepreneurship Monitor*. Global Entrepreneurship Research Association, London.

Slavtchev, V. and Göktepe-Hultén, D. (2015). Support for public research spin-offs by the parent organizations and the speed of commercialization. *The Journal of Technology Transfer*, **41**, 6: 1507–1525.

Smilor, R. W. (1997). Entrepreneurship: Reflections on a subversive activity. *Journal of Business Venturing*, **12**, 5: 341–346.

St-Jean, E. and Audet, J. (2012). The role of mentoring in the learning development of the novice entrepreneur. *International Entrepreneurship and Management Journal*, **8**, 1: 119–140.

St-Jean, E., Radu-Lefebvre, M. and Mathieu, C. (2018). Can less be more? Mentoring functions, learning goal orientation, and novice entrepreneurs' self-efficacy. *International Journal of Entrepreneurial Behavior & Research*, **24**, 1: 2–21.

Tartari, V., Perkmann, M. and Salter, A. (2014). In good company: The influence of peers on industry engagement by academic scientists. *Research Policy*, **43**, 7: 1189–1203.

Thursby, J. G. and Thursby, M. C. (2001). Industry perspectives on licensing university technologies sources and problems. *Industry and Higher Education*, **15**, 4: 289–294.

Tseng, C. C. (2013). Connecting self-directed learning with entrepreneurial learning to entrepreneurial performance. *International Journal of Entrepreneurial Behavior & Research*, **19**, 4: 425–446.

UTM Organisational Management Division (2016). Sejarah Penubuhan UTM. Universiti Teknologi Malaysia. Retrieved January 10, 2017 from http://registrar.utm.my/bpo/publication/panduan-staf-utm/tujuan/.

Vincett, P. S. (2010). The economic impacts of academic spin-off companies and their implications for public policy. *Research Policy*, **39**, 6: 736–747.

Walsh, S. T., Kirchhoff, B. A. and Newbert, S. (2002). Differentiating market strategies for disruptive technologies. *IEEE Transactions on Engineering Management*, **49**, 4: 341–351.

Willaby, H. W., Costa, D. S., Burns, B. D., MacCann, C. and Roberts, R. D. (2015). Testing complex models with small sample sizes: A historical overview and empirical demonstration of what partial least squares (PLS) can offer differential psychology. *Personality and Individual Differences*, **84**, 73–78.

Winkler, C., Fust, A. and Jenert, T. (2016). Differentiating novice, non-expert and expert entrepreneurs: A self-regulated learning perspective. In *Academy of Management Proceedings*, Vol. 2016, No. 1. Academy of Management, Briarcliff Manor, NY, pp. 12056.

Wood, M. S. (2011). A process model of academic entrepreneurship. *Business Horizons*, **54**, 2: 153–161.

Wright, M., Hmieleski, K. M., Siegel, D. S. and Ensley, M. D. (2007). The role of human capital in technological entrepreneurship. *Entrepreneurship Theory and Practice*, **31**, 6: 791–806.

Wright, M., Mosey, S. and Noke, H. (2012). Academic entrepreneurship and economic competitiveness: Rethinking the role of the entrepreneur. *Economics of Innovation and New Technology*, **21**, 5–6: 429–444.

Xavier, S. R., Kelley, D., Kew, J., Herrington, M and Vorderwulbecke, A. (2012). 2012 global report. *Global Entrepreneurship Monitor Report*. Global Entrepreneurship Research Association.

Yusof, M., Abdul-Samad, Z., Hassan, F., Darus, Z. M., Mohammed, M. F. and Zaharim, A. (2010). Academic Entrepreneurship and Innovation in Higher Education: An Integrated Framework for Malaysian Universities. In *6th WSEAS/IASME International Conference on Educational Technologies*, Sousse, Tunisia.

Zhang, Y., Duysters, G. and Cloodt, M. (2014). The role of entrepreneurship education as a predictor of university students' entrepreneurial intention. *International Entrepreneurship and Management Journal*, **10**, 3: 623–641.

Biography

Noorlizawati Abd Rahim is a Senior Lecturer at Science, Management and Design Department, Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia. Her current research interests are in the areas of entrepreneurship, academic entrepreneurship, entrepreneurial leadership, and entrepreneurship education. She has a multidisciplinary background in electronic engineering, postgraduate qualification in nanotechnology, PhD in entrepreneurship, with industrial experiences in chipset design and development, semiconductor manufacturing and technology commercialization from Intel, Freescale Semiconductor and NanoMalaysia respectively. Her teaching focuses on entrepreneurship, creativity and innovation management, quantitative data analysis, electronic systems and semiconductor materials engineering. She received her BEng in Electrical & Electronic Engineering from Cardiff University, MSc in Nanotechnology from University College London and PhD in entrepreneurship from Universiti Teknologi Malaysia.

Zainai Mohamed is an Emeritus Professor, who was the founder Vice Chancellor (VC) of Universiti Malaysia Kelantan (UMK), the 19th public university in Malaysia. Upon his retirement as the VC of UMK, he has returned to serve Universiti Teknologi Malaysia (since February 2012) as a senior professor. He has a wide experience not only as a Professional Civil Engineer but also in engineering and entrepreneurship education, curriculum development across multidiscipline, management of higher education, and teaching/research. He obtained his PhD in Structural/Civil Engineering from the University of Cambridge, England, Master and Bachelor's degree in Civil Engineering from University of Strathclyde, Scotland.

Astuty Amrin is a Professor at the Department of Engineering, Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia (UTM). Currently, she is the Dean of Razak Faculty of Technology and Informatics UTM. She received her Bachelor in Materials Engineering from Universiti Sains Malaysia, MSc in Corrosion Sc. and Eng. from UMIST, UK and PhD in 2005. Her research interest is devoted to Materials Engineering. Her teaching focuses on research methodology, technology management, creativity and innovation management, maintenance management, innovation & new product development, materials science and technology.

Maslin Masrom is an Associate Professor at Science, Management and Design Department, Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia. She received her Bachelor in Computer Science from Universiti Teknologi Malaysia, Master of Science in Operations Research from Western Michigan University, USA, and PhD in Information Technology/Information System Management from Universiti Putra Malaysia. Her teaching focuses on operations research/operations management, IT/IS management, knowledge management, and ethics in computing. Her current research interest includes IT-adoption, e-government, technology management, information security management, women and technologies, cloud computing, structural equation modelling, and creativity and innovation management.