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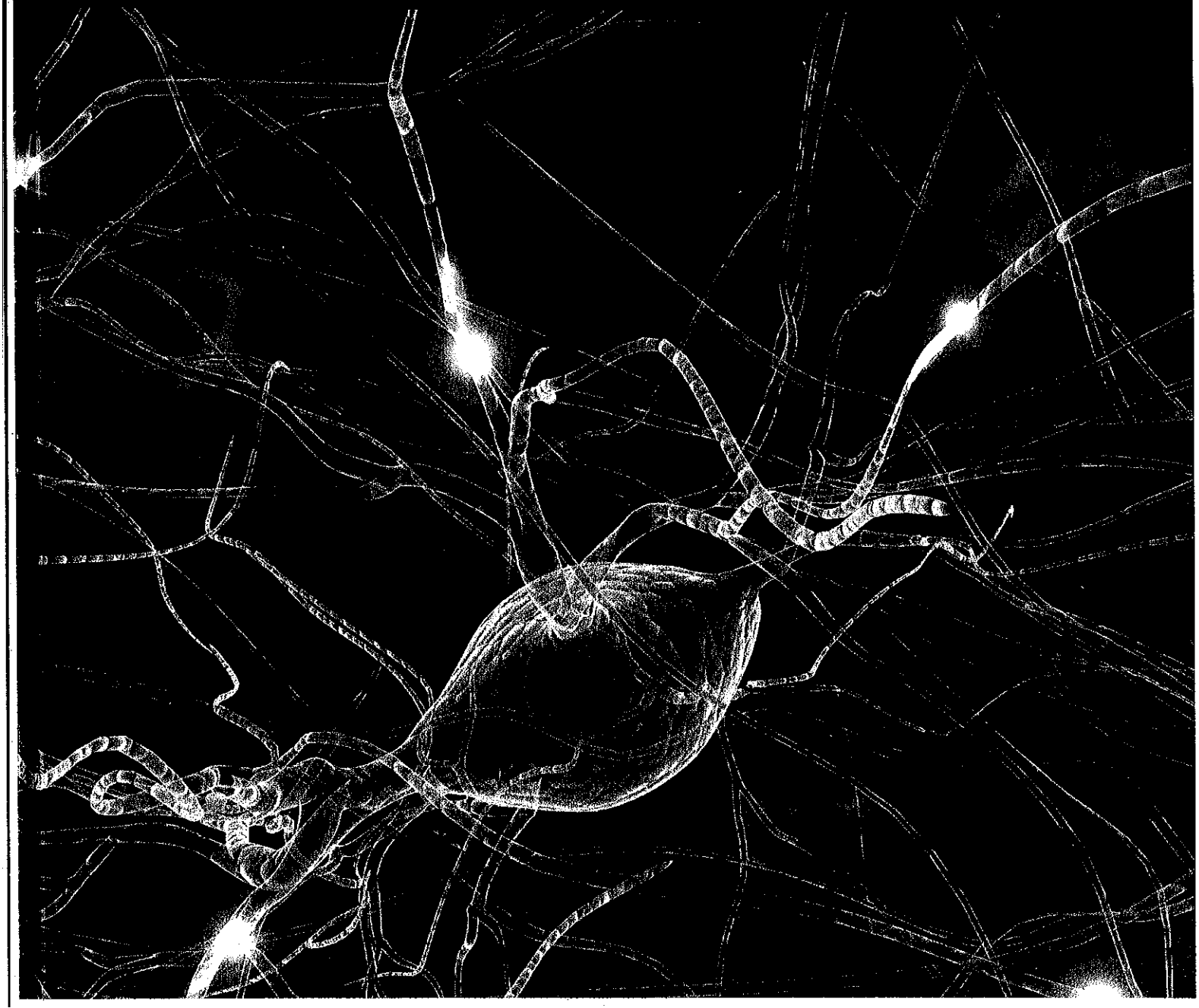
Handbook of Research on High-Technology Entrepreneurs

Edited by
Ayala Malach-Pines and Mustafa F. Özbilgin



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Edward Elgar
Cheltenham, UK • Northampton, MA, USA

Published by
Edward Elgar Publishing Limited
The Lypiatts
15 Lansdown Road
Cheltenham
Glos GL50 2JA
UK

Edward Elgar Publishing, Inc.
William Pratt House
9 Dewey Court
Northampton
Massachusetts 01060
USA

A catalogue record for this book
is available from the British Library

Library of Congress Control Number: 2009940639

ISBN 978 1 84720 949 8

Printed and bound by MPG Books Group, UK

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15 Entrepreneurial and other career motivations among engineering students

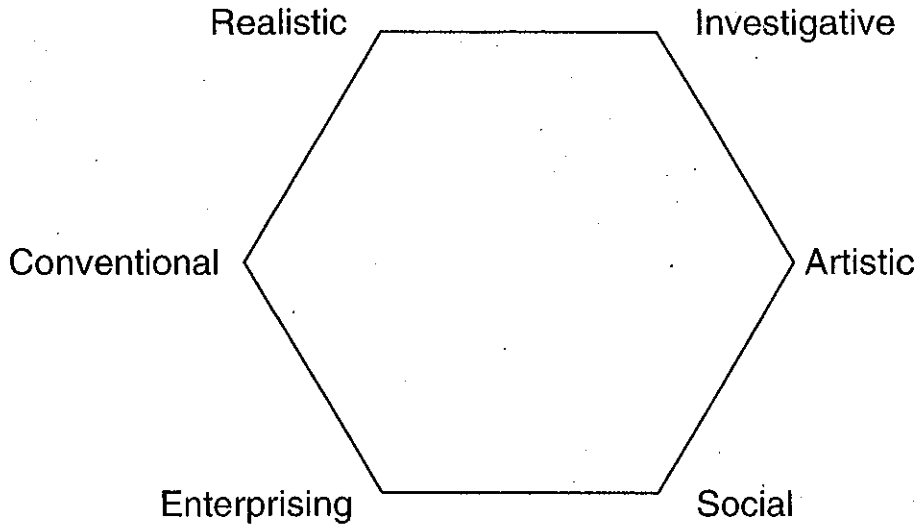
*Nilusha De Alwis and Helen M.G. Watt**

Introduction

Innovation is the key to entrepreneurship and engineers are some of the most influential contributors to innovation. Therefore, engineers have the potential to become successful entrepreneurs. An entrepreneur is an individual who creates or refines a business idea that would ultimately lead to the commercialisation of that product (Korunka et al., 2003). Likewise, an engineer creates a product that has not existed before, and is likely to improve the manner in which people live. For example, engineers in the past have not only become wealthy and successful entrepreneurs but have also created innovations which have changed civilisation. Technological achievements in electricity, transport and information processing have their roots in engineering (Arora and Faraone, 2003): Henry Ford changed America with the design and manufacturing of the Model T in 1907, the affordable family car that provided middle-class America with a sense of mobility that was never before dreamed of. His entrepreneurial mindset saw the creation of jobs and increase of the minimum wage which revolutionised society (Wicks, 2003).

With increasing emphasis on entrepreneurial skills in current engineering education (Nichols and Armstrong, 2003), the opportunity for engineers to become successful engineering entrepreneurs is present now more than ever. This potential for engineers to become entrepreneurs is recognised in Holland's occupational codes (Shears and Harvey-Beavis, 2001). Holland hypothesised six different groups or personality types into which individuals could be classified: 'realistic' (R), 'investigative' (I), 'artistic' (A), 'social' (S), 'enterprising' (E) and 'conventional' (C). The RIASEC hexagon is depicted in Figure 15.1. Types that are most likely to be closely related are presented next to each other, whereas types that are the least likely to be related appear opposite to one another (ibid.).

Holland's 'Self-Directed Search' assessment tool (ibid.) provides an estimate of the extent to which each of these types resembles an individual. Using these estimates, a three-letter code is developed, with the first letter resembling an individual the most, the second letter the next most, and the third representing the third most relevant characteristic. Similarly, three letter codes are provided for occupations, to allow for matching between



Source: Adapted from Shears and Harvey-Beavis, 2001.

Figure 15.1 Holland's RIASEC model

personality types and occupations. By these classifications, every engineering occupation (for example, computer engineer, environmental engineer, aeronautical engineer) is represented by the 'investigative' classification as either the first or the second letter (ibid.).

The characteristics of investigative types are presented in Table 15.1. Holland's 'enterprising' type, which is assumed to resemble entrepreneurship the most, is also presented in Table 15.1. Interestingly, almost half of the listed engineering occupations additionally include the enterprising classification as either the second or the third letter in their code. This suggests that those individuals who are attracted to an engineering career may be quite likely to possess enterprising or entrepreneurial interests.

It is a difficult task to identify characteristics that define engineers in general, due to the variety of engineering specialities. They are generally considered to be high in conscientiousness (Van der Molen et al., 2007) and highly knowledgeable (Frank, 2006), which when combined can optimise success. Characteristics of successful entrepreneurs have been well documented (see, for example, Dvir, Sadeh and Pines, ch. 1, this volume). Their key personality characteristics have been identified as: need for achievement, internal locus of control, autonomy, creativity, problem-solving skills, tolerance of ambiguity or uncertainty, risk-taking behaviour, leadership and assertiveness (Korunka et al., 2003; Caliendo and Kritikos, 2008; Athayde, 2009). It is possible that potential entrepreneurial engineers may not be aware of their capabilities or of the entrepreneurial career possibilities related to the field of engineering. Conversely, those who have clear entrepreneurial intent may not be able to pursue their goals

Table 15.1 Interests and special characteristics of investigative and enterprising personality types

	Investigative	Enterprising
Most enjoy	Reading and thinking about solutions to problems	Holding a position of power
Life goals	Contributing to scientific theory and knowledge	Financial success Being influential in public affairs Having executive responsibility
Values	Intelligence Logic Achievement Knowledge	Ambition Freedom Financial success Risk taking
Sees self as having	Maths ability Scientific ability Research ability	Popularity Leadership
Dislikes	Leading or persuading others	Scientific or theoretical problems
Most competent in	Science	Leadership

Source: Adapted from Shears and Harvey-Beavis, 2001.

due to reasons such as finances or lack of guidance as to how to begin a venture. Hence, there is a need to identify potential entrepreneurial engineers at the outset of their tertiary career. By identifying these individuals, support, development and recruitment can be provided. One approach to identifying potential entrepreneurial engineers is to distinguish those who possess entrepreneurial type career motivations from those who do not. A similar approach is suggested by Ronen (ch. 13, this volume) who focused on 'intrapreneurship' – entrepreneurial skills and approaches adopted by high-technology engineers employed in entrepreneurial firms.

The present study

The present study set out to establish the prevalence of one aspect of entrepreneurship – the 'career ladder' – as a career motivation among engineering students at the outset of their undergraduate studies. This motivation measured the importance of climbing the career ladder and promotional prospects in individuals' career choice, which relates to the ambition and success aspect of entrepreneurship. The 'Motivations for Career Choice' (MCC) scale (Watt and Richardson, unpublished) incorporates items which measure this 'career ladder' motivation (for example,

'has a career "ladder" I can climb'), as part of a broader set of career motivations.

In the present study, the goals were, first, to measure the perceived importance of career ladder motivations, relative to other career motivations, among this sample of beginning engineering students; and second, to explore which other career motivations were held by individuals scoring high on career ladder motivations. Identifying those with high career ladder motivations implies that these people could be provided with additional support and training in entrepreneurship, if the aim is to encourage engineers into an entrepreneurial career. Knowledge of which other career motivations accompany career ladder motivations will further yield understanding of these individuals' goals, and discern which other career motivations relate to 'career ladder' ambitions. It is important to explore the prevalence and extent of entrepreneurial ambitions among normative samples of engineering students, which, based on the preceding review, could be anticipated to be important and salient goals within this population. If this is so, engineering courses may prove a fruitful arena within which to recruit and scaffold future entrepreneurs.

Previous research has examined influences, aspirations and motivations among 2,330 1st year engineering students enrolled at the Faculty of Engineering at Imperial College London (Alpay et al., 2008), in which respondents were requested to select one answer from a range of options for questions relating to their motivations and aspirations. In that study, more than a quarter of the students stated their enjoyment of mathematics and physics as their most important reason for choosing engineering. The current study builds and extends on this foundation, through assessing the *extent* to which a range of motivations are important, rather than participant selection of only one aspiration or motivation, using a rigorously developed and theorised MCC scale (Watt and Richardson, unpublished). This scale is firmly grounded in expectancy-value motivation theory (Eccles et al., 1983), and includes a comprehensive range of career motivations summarised in Table 15.3.

Findings from Lent et al.'s (2008) programme of Social Cognitive Career Theory (SCCT) research among 1st year engineering students has shown that confidence in one's abilities will lead to persistence goals in a given domain, such as career intentions within that domain. Based upon the collective findings that interests and perceived abilities influence the decision to pursue an engineering career, the MCC scale career motivation 'abilities and interests' could be expected to be rated highly among engineering students.

Alpay et al. (2008) found that the most consistent influence on the decision to pursue engineering was the parents. Therefore, 'social influences'

was expected to be rated as an important motivation. Their results also indicated that engineering students' pre-university aspirations were inventing something new, making a difference to the world, financial security, travelling the world, or respect from family and friends. Therefore, the following MCC career motivations were expected to be rated as important among the current sample: 'social contribution', 'enhancing social equity', 'salary', 'travel' and 'social status'.

Since students may be unlikely to have chosen to study engineering if they did not plan to pursue an engineering career, 'content knowledge' (the MCC motivation to pursue a career in the area of their university studies) was expected to be rated as an important motivation. 'Cognitive challenge' and 'expert career' were also expected to be rated as highly important, because engineering is a field that involves highly specialised knowledge. It was interesting to explore how important the remaining career motivations were: 'personal mobility', 'teamwork', 'time for family', 'job flexibility', 'autonomy', 'bludging' (that is, applying little effort to tasks), and 'work with children to shape future'.

In terms of which career motivations were expected to relate to the 'career ladder' aspect of entrepreneurial intent, 'salary', 'cognitive challenge', 'autonomy', 'job flexibility', 'personal mobility', and 'social status' motivations were hypothesized to be related. The reasoning was as follows: a significant positive relationship was anticipated for 'salary', since financial success is said to be a goal of Holland's 'enterprising' type (Shears and Harvey-Beavis, 2001) and past research has shown that increased income was a motivator among aspiring entrepreneurs (Cromie, 1987; Luthje and Franke, 2003). For 'cognitive challenge' and 'autonomy', positive associations were expected because problem-solving skills and autonomy have been previously identified as key characteristics of entrepreneurs (Caliendo and Kritikos, 2008; Athayde, 2009). For 'job flexibility' and 'personal mobility', a link with the desire to exert control over one's personal and professional life, was anticipated because an internal locus of control has been previously identified as a major characteristic of entrepreneurship (Caliendo and Kritikos, 2008). For 'social status', a multi-country survey has revealed that the perceived high status of entrepreneurship predicted interest in entrepreneurship (Begley and Tan, 2001). Other relationships were considered likely, although no specific hypotheses were made.

Method

Participants

Participants (N = 108) were 1st year engineering students enrolled in three Australian universities who volunteered to participate in the

Table 15.2 Mean ages for participants in each university and for each gender

	Monash University	Melbourne University	University of NSW	Total
Full sample	$n = 74$	$n = 12$	$n = 22$	$n = 108$
Age in years	M = 18.69	M = 18.50	M = 18.59	M = 18.65
	SD = 0.96	SD = 0.52	SD = 0.77	SD = 0.89
Males	$n = 47$	$n = 8$	$n = 17$	$n = 72$
Age in years	M = 18.89	M = 18.63	M = 18.71	M = 18.82
	SD = 1.07	SD = 0.51	SD = 0.77	SD = 0.95
Females	$n = 27$	$n = 4$	$n = 5$	$n = 36$
Age in years	M = 18.33	M = 18.25	M = 18.20	M = 18.31
	SD = 0.62	SD = 0.77	SD = 0.83	SD = 0.62

survey. Since 1st year students would have had to make their final decision to pursue engineering by the previous year, a clear and salient view of career choice was expected. Seventy-four students came from Monash University (see De Alwis, 2008), 12 from Melbourne University (see Brown, 2007), and 22 from the University of New South Wales (UNSW; see Young, 2007). Participants were variously recruited by email invitations to complete an online version of the MCC scale (Monash) and through residential colleges (Melbourne and UNSW). The average ages of participants in each university and for each gender are presented in Table 15.2.

Materials

The MCC scale (Watt and Richardson, unpublished) was developed to assess career motivations among diverse populations. The MCC has four major sections. The first section, 'about you', asked for information such as participants' age, gender, and the degree in which they were enrolled. Immediately following is the 'your career plans' section, which asked participants to nominate their ideal career. In the third section, factors influencing career choice were assessed. Sixty-four items were presented and participants were requested to rate on a scale from 1 (not at all) to 7 (extremely), how important each item was to choosing their career ('It is important to me to have a career that . . .'). These 64 items represent 18 career motivation factors including the career ladder factor, displayed in Table 15.3 with accompanying Cronbach alphas to demonstrate sufficient reliabilities. The final section elicited demographic information relating to parents' country of birth, qualifications, occupation and income.

Table 15.3 MCC factor descriptions and Cronbach alphas

Factors	Cronbach's alpha	Sample item
Career ladder	0.79	Provides a clear pathway for career development
Enhance social equity	0.89	Allows me to work against social disadvantage
Salary	0.84	Earns a good salary
Bludging	0.84	Has a light workload
Social influences	0.72	Is a career my family think I should pursue
Teamwork	0.93	Involves working as part of a team
Expert career	0.87	Involves highly specialised knowledge
Working with children to shape the future	0.82	Allows me to influence the next generation
Social contribution	0.75	Allows me to make a worthwhile social contribution
Abilities and interests	0.77	Matches my interests
Time for family	0.85	Fits vacation time with family commitments
Autonomy	0.69	Lets me work mostly by myself
Content knowledge	0.82	Is strongly related to my university studies
Travel	0.81	Allows me to work internationally
Personal mobility	N/A*	Allows me to choose where I live
Job flexibility	N/A*	Offers job flexibility (e.g. part-time options)
Cognitive challenge	0.67	Gives me the chance to participate in decision making
Social status	0.77	Is a high-status career

Note: *N/A for single-item scale indicators.

Results

Demographics

Demographic information to describe the sample is presented in Table 15.4. As depicted in the table, the majority of the sample – more than 80 per cent – came from an English-speaking background, and more than half had Australian-born parents. Other participants had parents born in a range of countries including Malaysia, England, Sri Lanka, New Zealand and China.

Table 15.4 Demographic information for the present sample

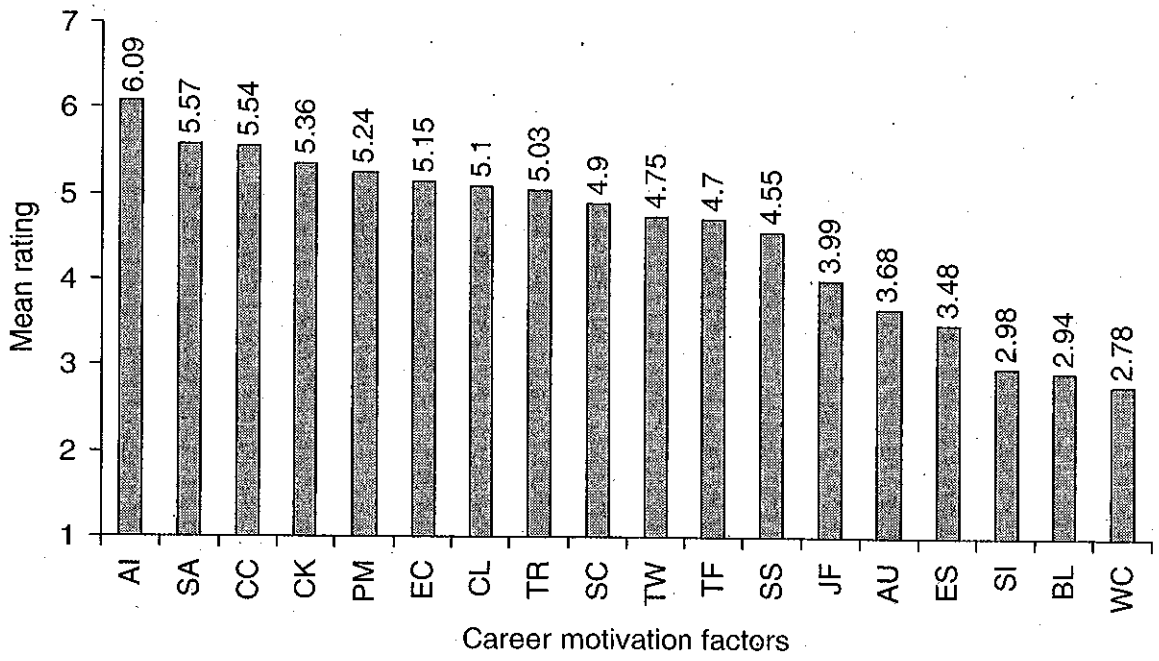
	N	Valid %	Total responses
English-speaking background	86	80.4	107
Indigenous students	1	0.9	107
Australian-born fathers	50	58.8	85
Australian-born mothers	54	64.3	84
Fathers with an undergraduate qualification or higher*	54	62.1	87
Mothers with an undergraduate qualification or higher*	48	57.1	84
Combined parental income throughout participants' high-school years > $90,000	47	61.0	76

Note: *Postgraduate diplomas, postgraduate degrees, PhDs.

Career motivations

The importance of each career motivation within the sample is portrayed in Figure 15.2. The factor 'abilities and interests' was rated as the most important, whereas 'career ladder' was rated seventh. Other important motivations ahead of 'career ladder' included 'salary', 'cognitive challenge', 'travel', 'content knowledge', 'personal mobility' and 'expert career'. Important motivations which were rated lower than 'career ladder' included 'social contribution', 'teamwork', 'time for family' and 'social status'. The motivations that were rated as of low importance (that is, rated below the scale midpoint), were 'job flexibility', 'autonomy', 'enhance social equity', 'social influences', 'bludging' and 'work with children to shape future'. No gender differences in career motivations were identified ($p > 0.05$ in ANOVA tests) suggesting that female and male engineering students in this sample did not differ in what they desire from their career.

Pearson bivariate correlations between 'career ladder' and all other 17 measured career motivations revealed significant associations with several, including 'social status', 'salary', 'expert career' and 'teamwork'. The right side of Figure 15.3 shows career motivations that were statistically significantly correlated with career ladder (depicted in bold). Motivations that did not correlate significantly are presented on the left side of the figure ('autonomy', 'enhance social equity', 'social contribution', 'job flexibility', 'abilities and interests', 'time for family', and 'work with children to shape the future').

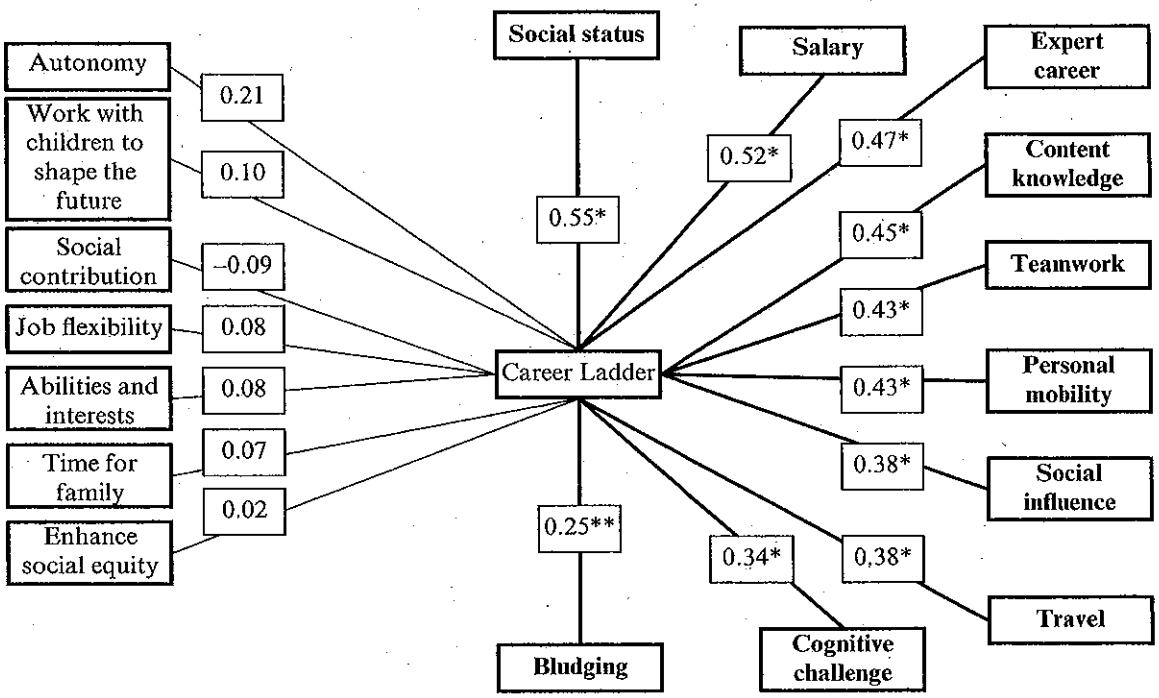


Abbreviations
AI: Abilities and interests; SA: Salary; CC: Cognitive challenge; CK: Content knowledge; PM: Personal mobility; EC: Expert career; CL: Career ladder; TR: Travel; SC: Social contribution; TW: Teamwork; TF: Time for family; SS: Social status; JF: Job flexibility; AU: Autonomy; ES: Enhance social equity; SI: Social influences; BL: Bludging; WC: Work with children to shape future.

Figure 15.2 Mean ratings for career motivations

Discussion

'Career ladder' was an important career motivation among 1st year engineering students, suggesting potential entrepreneurial motivations as anticipated. The 'career ladder' motivation was preceded in importance by other motivations: 'abilities and interests', 'salary', 'cognitive challenge', 'content knowledge', 'personal mobility' and 'expert career'. The fact that 'abilities and interests' was the highest rated career motivation supports Lent and et al.'s (2008) findings within their SCCT, which posits that confidence in one's abilities predicts persistence goals such as career choice. This result also resonates with the findings of Alpay et al. (2008), that interest, or 'enjoyment of mathematics and physics' was the most important reason selected by students for pursuing engineering. Contrary to our predictions, based on Alpay et al.'s study 'social influences' was not rated as an important career motivation, but instead as third lowest. While Alpay et al. had found that the most important social influence on aspirations to study engineering was parents, the current study did not find that social influences were rated as high in importance. The reason may partly lie in the operationalisation of 'social influences' as including parental



Note: $*p < 0.01$; $**p < 0.05$.

Figure 15.3 Correlations between career ladder and each MCC factor

influences alongside friends and workmates, whereas Alpay et al. focused on parents alone. More importantly, their study asked participants to respond to the question 'who most influenced your decision to study engineering?' to produce a *relative* judgement, not providing information regarding their *extent* of influence. Consequently, the fact that parents were nominated as the 'most' influential group, need not necessarily imply that parents were *very* influential.

Based upon Alpay et al.'s study, it had been predicted that 'social contribution', 'salary', 'travel', 'social status' and 'enhancing social equity' would be highly rated career motivations. Findings indeed indicated that the first four of these motivations were rated as highly important in career choice although 'enhancing social equity' was rated as fourth lowest. It is encouraging that, while wealth was an important motivator, contributing to society was also regarded as a high priority. It was initially somewhat surprising that while 'social contribution' was rated high, 'enhancing social equity' was rated low. This suggests that while engineers aim to contribute to society, they do not see themselves as doing this through helping the socially disadvantaged and underprivileged. It seems that these engineering students would prefer to contribute to society by other means, perhaps through innovation or renovation of useful products. The hypotheses that 'content knowledge', 'cognitive challenge' and 'expert career' would be

important career motivations were supported. The remaining motivations which were not hypothesised about were 'personal mobility', 'teamwork', 'time for family', 'job flexibility', 'autonomy', 'bludging' and 'work with children to shape future'. In fact, the first three of these were all rated as important motivations, revealing that the engineering students desired careers which will allow them to live where they choose, that involve teamwork, and allow time for family. 'Job flexibility', 'autonomy', 'bludging' and 'work with children to shape future' were not rated as important. The 'job flexibility' motivation relates to wanting a career that has part-time options, 'autonomy' refers to working by oneself, while 'bludging' refers to having a career that requires less work and a short working day. The fact that these motivations were rated low is encouraging because it may suggest that these students would prefer to work hard in their respective career. Considering that these students would prefer a career that involves teamwork, it is not surprising that working alone was not something they desired. Similarly, these students did not have a desire for a career that would provide opportunities for them to work with children and adolescents.

As predicted, 'salary' correlated significantly with 'career ladder' in a positive direction. Given that an increased income has been found to be a motivator among aspiring entrepreneurs (Luthje and Franke, 2003; Cromie, 1987) this relationship was not unexpected. However, a study investigating the founding motivations among high-technology entrepreneurs revealed that wealth attainment was their lowest-ranked motivator (Amit et al., 2001), although that does not suggest that financial success does not motivate entrepreneurship at all. It is possible that those findings reflect changing career motivations through one's career progression, in this case perhaps particularly if wealth has already been attained.

The results also indicated the presence of a positive significant relationship between 'career ladder' and 'cognitive challenge', which supported the hypothesis. The 'cognitive challenge' career motivation is defined by the need to have a career that provides opportunities to work on difficult and challenging problems as well as being able to participate in decision making (Watt and Richardson, unpublished). A successful entrepreneur is said to possess a problem-solving orientation (Caliendo and Kritikos, 2008), providing support for our hypothesis. Contrary to what was expected, a significant positive association between 'career ladder' and 'autonomy' was not found. This seeming contradiction is likely due to that definition of autonomy as having personal control, whereas the MCC operationalisation of autonomy relates primarily to working alone (Watt and Richardson, unpublished), thereby tapping a qualitatively different aspect.

If internal locus of control is a key characteristic of entrepreneurs (Caliendo and Kritikos, 2008), as speculated, one might expect that they would have preferred to control most aspects of their life such as where they would live and how flexible their career would be. While 'personal mobility' correlated positively with 'career ladder', 'job flexibility' did not, implying that this was not regarded as relevant to ambitions for career progression. Those who rated 'career ladder' as an important motivation also rated 'social status' as important, which, as anticipated, suggests that those who are likely to be motivated by climbing the career ladder are also likely to be motivated by career status. Being a high-technology entrepreneur is typically considered a high social status occupation and so this result is not surprising in our context. Providing support for this notion, past research has found that the perceived social status of entrepreneurship predicts interest in entrepreneurship (Begley and Tan, 2001).

Other motivations that correlated positively with 'career ladder' included 'expert career', 'content knowledge', 'teamwork', 'social influence' and 'travel'. Therefore, those who exhibited entrepreneurial motivations in terms of career ambition would also prefer to have an expert career, related to their university studies, and involving teamwork and travel opportunities. Surprisingly, 'bludging' motivations related significantly *positively* although weakly with 'career ladder', suggesting that individuals exhibiting this aspect of entrepreneurial characteristics (that is climbing the career ladder) tended to prefer to put in less effort to attain this. The most notable non-significant relationships between 'career ladder' and other measured career motivations were for 'social contribution' and 'abilities and interests', which although rated high, were unrelated to 'career ladder' motivations. This demonstrates that, although engineering students are motivated by their abilities, interests and desires to make a social contribution, these goals are independent of their personal ambition for career progression.

Contributions and future directions

The current study contributed to research relating to high-technology entrepreneurship by establishing the prevalence of the motivation to climb the career ladder, which was assessed as one aspect of entrepreneurship, among a sample of 1st year engineering students. The study has found that the desire to climb the career ladder is an important motivation among these students. Furthermore, the study measured a range of motivations that influenced prospective engineers' career choice, and their interrelationships. The manner in which these motivations were assessed by use of the MCC scale (Watt and Richardson, unpublished) was unique, in that respondents rated the importance of *each* motivation, allowing the

assessment of more than one variable influencing career decision. This study thus extends and builds upon the previous study of engineering students' motivations (Alpay et al., 2008), which investigated the *relatively* most important motivation or influence on studying engineering at university, but not the extent of such influences. The study is also unique in its measure of a different aspect of entrepreneurship, career ladder, whereas past studies have looked at other aspects, including risk-taking propensity, locus of control, and salary (Cromie, 1987; Luthje and Frank, 2003).

Admittedly, the career ladder aspect of entrepreneurship does not describe the totality of entrepreneurial career motivations. Future studies could fruitfully assess the strength of relationships between other entrepreneurial aspects (for example, wealth attainment, locus of control, risk-taking propensity) and the comprehensive set of MCC career motivations, to identify potentially additional or different relationships with other dimensions of entrepreneurial motivations. An area that the study did not address due to the MCC questionnaire format was specific entrepreneurial intent. Future research in this vein could include specific questions to enquire about participants' intentions to create something new and start a business with their product. This would help further establish prevalence of entrepreneurial intent, and also permit comparisons between those who do versus do not express such goals.

The study sampled 1st year engineering students, to address the first goal regarding the prevalence and extent of entrepreneurial type career motivations among engineering students at the very outset. It is possible that motivations and entrepreneurial intent may become clearer and change as students progress through their degrees. Hence it would be interesting for future research to study the patterns of change and factors that may affect changes in entrepreneurial intent across the duration of individuals' university studies. It would also be beneficial if entrepreneurial intent and characteristics were established for each field within engineering (for example, chemical, mechanical, environmental) to reveal whether differences exist between specialisations.

Attempts to focus on *all* students in efforts to market entrepreneurship as a career path is not a viable strategy. This is mainly because certain personality types are better suited to entrepreneurship than others. It is therefore advisable to direct programmes to encourage students to pursue entrepreneurship towards those who exhibit entrepreneurial-type motivations or characteristics (Luthje and Franke, 2003). To do so, entrepreneurial-type motivations and characteristics first need to be identified. The current study has taken first steps in this direction, by identifying engineering students who hold entrepreneurial-type career motivations on the dimension of 'career ladder' motivations.

Note

* We are grateful for permission to use the Motivations for Career Choice scale (MCC, Watt and Richardson, unpublished), and to Amy Young and Amy Brown for allowing us to include relevant parts of their data in our study.

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