Determining and Classifying Factors of Employees' Expatriation Willingness Using Rough Set Theory

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Abstract: The objective of this research is to identify and classify the factors affecting the expatriation willingness (EW) of engineering consulting company employees. A total of 13 EW impact factors are summarized from a review of the literature and divided into four categories. From the collected factors and expert interviews, 22 impact factors are obtained and divided into eight categories, with the exception of demographic variables. A survey aiming at the top five engineering consulting companies is carried out. Out of a total of 1,000 questionnaires sent out, 41.3% valid responses are returned. The statistical analysis shows that the survey is reliable and one of the 22 factors is removed. Rough set theory (RST) is utilized to classify these factors into three classes based on impact level. The conclusions provide practitioners with six core impact factors on employees' EW. The findings can be of benefit to employers, helping them to save recourse and to target the most appropriate employees for expatriation. **DOI: 10.1061/(ASCE)ME.1943-5479.0000206.**

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Introduction

In recent years, along with governmental assistance for engineering consultant companies in Taiwan, the demand for individuals willing to relocate internationally has increased. These consultant companies have conducted business in areas including planning, design, construction, construction management, engineering consulting, and procurement. Even though previous studies regarding human resources have recommended various strategies (Brandenburg et al. 2006, 2009; Han et al. 2008; Xue et al. 2010; Shen et al. 2011; Lin 2011), as these companies expand into foreign markets, it has been found that it is often difficult for expatriates to work in overseas environments. However, it is revealed in the literature that expatriates are a source of competitiveness for an enterprise in the global market and are helpful in developing new markets (Takeuchi et al. 2005; Yan et al. 2002). Promoting successful expatriation is important for achieving this goal (Shaffer and Harrison 1998). *Expatriation willingness (EW)*, which is candidates' willingness to accept expatriate assignments, is one of the keys to success (Tung and Miller 1990). With the change in social values in recent years, employees' views toward EW have changed gradually. For example, past studies have shown that male employees are more willing to relocate abroad than female employees (Yan et al. 2002; Stroh et al. 2000), and that age is negatively correlated to their EW (Gould and Penley 1985; Landau et al. 1992). However, recent empirical evidence seems to challenge these findings. A new survey for quantification of employee EW is desperately needed for engineering consulting companies trying to enter or remain in international markets.

The objective of this study is to explore changes in EW and to determine and classify factors affecting this willingness for engineering consulting firms. The study is specifically aimed at employees serving in large-scale engineering consulting companies, who have overseas work experience. The modified Delphi method is used to obtain expertise during the initial stage. A questionnaire is developed based on a survey of the literature and from expert interviews. This specifically fits an area that has a limited number of research papers (e.g.,Chen and Hsu 2008) and is followed by comprehensive analysis of the explored factors. Rough set theory (RST) is applied to classify the core and regular factors based on their significance. RST has widely been applied in numerous studies starting in 1982 (Pawlak 1982; Zhong et al. 2001; Pawlak 2002, 2004; Mafakheri et al. 2007; Zhang and Xu 2009; Shyng et al. 2010). For example, Kim et al. (2009) utilized the RST approach to determine the category of causes for insufficient and imprecise crack characteristics observed in regular inspections of concrete structure. The rules extracted by RST offer better explanatory information from the data themselves without applying any assumptions, compared with other decision-making techniques such as neural networks and decision trees (Mak and Munakata 2002; Huang et al. 2010). Moreover, RST performs better when the data are incomplete or imprecise (Grzymala-Busse and Grzymala-Busse 1995). These advantages of RST show that it is a suitable method to be employed in this study.

Expatriation Willingness

This section provides a discussion for the factors noted in previous studies that influence employees' EW founded on (1) demographic variables, (2) family influence, (3) company expatriation policy, and (4) expatriate location. Selmer and De Leon (2001) argued that demographic characteristics are important indicators for predicting expatriation. These findings show the importance of demographic variables for identifying those employees who have positive EW. Although those research studies based on surveys in the

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United States indicated that there is no significant difference between male and female willingness to accept international assignments (Adler 1984, 1986; Hill and Tillery 1992; Tung 1998), women have been reported to be less willing to relocate than men if the expatriate assignment is in a culturally dissimilar location. Women's unwillingness to accept an expatriate assignment may well stem from the differences in gender behaviors. For this reason, women may be more willing to accept an expatriate assignment in a culturally similar location than a culturally dissimilar location (Aryee et al. 1996). Numerous studies agreed that employees' EW is inversely proportional to age (Gould and Penley 1985; Landau et al. 1992). Their findings indicated that employees over 45 tend to have lower expectation of promotion than those aged between 25 and 30. Moreover, these employees' EW reduces as their ages increase. In terms of education background, Brett and Stroh (1995) have pointed out that employees with relatively higher education are more adaptable at accepting expatriation. Their EW is typically higher than that of those with relatively lower education. It is usually easier for employees with previous expatriation experience to adapt than those without that experience (Louis 1980). These studies, furthermore, specified a positive correlation between overseas work experience and EW (Ronen 1989; Black and Mendenhall 1990; Borstorff et al. 1997).

Family influence means that family members often affect individual behavior (Minuchin 1974). Richardson (2006) noted that certain family members (particularly spouses and children) play a strong role in determining EW. Previous studies showed that a married individual with spousal support has more of an inclination to take foreign expatriation (Brett and Stroh 1995; Harvey and Buckley 1998; Konopaske et al. 2005). Health care and children's educational considerations also have an effect on employees' EW (Brett and Reilly 1988; Dessler 1998). Brett and Reilly (1988) noted that employees are unwilling to transfer their employment once they are responsible for taking care of children. This was because overseas expatriation may affect their children's schooling and social network. A well-designed corporate expatriation policy also often increases employees' EW (Harvey 1989). In other words, companies that provide training for expatriates may encounter fewer impediments (Yates 1989; Barco 1994). Financial incentives also can intensify employees' EW, leading to success in international expatriation management (Noe et al. 1988; Black and Gregersen 1991; Feldman and Thomas 1992; Al-Subhi Al-Harbi 1997; Richards 1999). Companies arranging repatriation programs not only help to lower employees' stress, but also improve expatriation stability (Tasar 2000). Expatriate location typically also has an effect on employees' EW (Adler 1991; Aryee et al. 1996). One study found that EW depends on the economic level of the expatriate location (Adler 1986). Locations with higher levels of development and economic status intensify employees' intentions for expatriation (Adler 1991). Similarity of culture also attracts employees to take expatriate assignments (Mendenhall et al. 1987). The lower the culture barrier the expatriate site has, the higher the EW presented by the employees is (Yan et al. 2002). As companies continue to move or spread to locations abroad, culture gradually plays an important role (Di Marco et al.2010; Comu et al. 2011). Detailed citations for these four categories are shown in Table 1.

Data Collection and Analysis

Pilot Survey

Based on the factors summarized in Table 1, a pilot survey was carried out to acquire expertise from interviews, targeting high-ranking managers (at least senior division managers) from the top five engineering consulting companies in Taiwan. Each company recommended two senior managers to be interviewed. A total of ten division heads with the corresponding positions of five vice presidents and five senior managers were interviewed. Based on the interviews, the restructured factors are listed in Table 1. The training program for expatriation was deleted and two categories related to personal safety and health care, and two factors related to loneliness and expatriation duration were added. The other factors remained the same or similar to the original sources.

Engineering consulting companies in Taiwan entered the international construction market relatively late. Markets in southeastern and western Asia are their major targets. The cultures, religions, and lifestyles in these areas are extremely different from those of Taiwan. For example, some social behaviors and values that might be normal in Taiwan could be considered insulting in these regions. The unforeseen impact of such cultural differences could be harmful to the personal safety of the employees. The experts suggest that the category of personal safety should include the factors of protection, local hostility, and social security. The protection factor presents a defense level that individuals may prepare for. Local hostility is regarded as a hostile level in the assigned expatriate area that individuals may receive or be aware of.

Table 1. Major EW Impact Factors

Category	Impact factor	Source
Demographic variables	Gender	Stroh et al. (2000), Wan et al. (2003)
	Age	Gould and Penley (1985), Landau et al. (1992), Brett et al. (1993), Veiga (1983)
	Education	Brett and Stroh (1995), Adler (1986)
	Marital status	Borstorff et al. (1997)
	Overseas living experience	Ronen (1989), Borstorff et al. (1997)
	Overseas expatriation experience	Black and Mendenhall (1990), Louis (1980)
Family influence	Spousal support	Richardson (2006), Konopaske et al. (2005), Borstorff et al. (1997), Harvey and Buckley (1998), Brett and Stroh (1995)
	Attitude toward child care	Richardson (2006), Dessler (1998), Landau et al. (1992), Gould and Penley (1985)
Expatriation policy	Repatriation program	Harvey (1989), Adler (1986), Aryee et al. (1996)
	Career planning	Adler (1986), Landau et al. (1992)
	Providing training	Yates (1989), Black and Gregerson (1991), Feldman and Thomas (1992), Barco (1994), Aryee et al. (1996)
	Financial compensation	Noe et al. (1988), Gregersen and Black (1992), Aryee et al. (1996), Richards (1999)
Expatriate location	Cultural difference	Adler (1991), Aryee et al. (1996), Mendenhall et al. (1987)
	Economic development	Adler (1991)

Table 2. Summary of Impact Factors

Category	Number	Impact factor	Category	Number	Impact factor
Demographic variables		Gender	Economy of location	10	Economic development
		Age		11	Price index
		Education		12	Gross domestic product (GDP)
		Marital status	Culture	13	Customs and habits
		Overseas living experience		14	Religion
Personal safety	1	Protest	Family	15	Marital status
	2	War		16	Child care
	3	Local hostility		17	Family care
	4	Social security		18	Family support
Health care	5	Environmental health	Expatriation policy	19	Salary and welfare
	6	Medical standard		20	Subsidies
	7	Medical accessibility		21	Repatriation plan
Project	8	Expatriation duration		22	Possible promotion
	9	Personal loneliness			

Social security indicates an overall safety level that may influence individuals.

The health care category takes into account the health of the expat's children and spouse. If the projects for which the expat is responsible have infrastructure near a desert or a swamp, it could be considered a hostile environment. The availability of adequate health care programs plays an important role in EW. The factors included in the health care category are environmental health, medical standards, and medical accessibility. Environmental health is an environment that directly harms individuals. Medical standards specify a basic medical attention level in the expatriate's area. Medical accessibility is how easy it is for individuals to receive medical attention. The scale of a project might mean that a single employee would have few (or even no) social activities for a long period of time, leading to loneliness. Thus, the number of expatriates working on a project is positively related to employees' EW. The duration of expatriation, on the other hand, is negatively related to employees' EW. These two factors are classified within the project category. Table 2 shows the restructured categories and the corresponding impact factors.

Questionnaire Design and Survey

The questionnaire was developed based on the 22 factors listed in Table 2, using the widely accepted 5-point Likert scale. The five impact levels were defined as "extremely high impact," "high impact," "medium impact," "low impact," and "little or no impact." Combining five demographic variables, the study finalized 22 items and then randomly distributed 1,000 questionnaires to employees working at the top five engineering consulting companies. Within a month, 486 questionnaire responses were returned. Of these, 73 out of 486 returned questionnaires were invalid, resulting in an acceptance rate at 41.3%. To ensure that the reliability of the returned questionnaires met the threshold at Cronbach's $\alpha = 0.8$ (Hair et al. 1998; Chen and Hsu 2008), a total of 413 valid questionnaires were included. As can be seen in Table 3, each Cronbach's α value is greater than the threshold, which determines the necessity for further analysis.

Data Analysis

The basic analysis for the demographic variables is summarized in Table 4. It sheds light on the reality of the engineering consulting

Table 3. Test Results

Factor	Missing value	Mean	Standard deviation	Skewness	T-test	Correlation coefficient	Factor loading	MSA	Cronbach's α
Protest	0.00	4.356	0.786	−1.112	0.000	0.375	0.405	0.82	0.890
War	0.00	4.736	0.536	−2.408	0.000	0.272	0.302	0.78	0.891
Local hostility	0.00	4.269	0.723	−0.611	0.000	0.379	0.424	0.87	0.889
Social security	0.00	4.286	0.654	−0.529	0.000	0.522	0.563	0.90	0.887
Environmental health	0.00	3.889	0.765	−0.169	0.000	0.581	0.657	0.89	0.885
Medical standards	0.00	3.862	0.768	−0.017	0.000	0.625	0.710	0.85	0.884
Medical accessibility	0.00	3.792	0.757	−0.004	0.000	0.613	0.701	0.89	0.885
Expatriation duration	0.00	2.976	0.769	0.041	0.000	0.489	0.460	0.92	0.887
Personal loneliness	0.00	3.947	0.808	−0.375	0.000	0.482	0.502	0.83	0.887
Economic development	0.00	3.567	0.937	−0.301	0.000	0.512	0.572	0.94	0.887
Price index	0.00	3.031	0.822	0.126	0.000	0.456	0.481	0.83	0.888
GDP	0.00	2.772	0.813	−0.077	0.000	0.448	0.495	0.83	0.888
Customs and habits	0.00	2.838	0.822	0.071	0.000	0.578	0.637	0.88	0.885
Religion	0.00	2.726	0.881	0.157	0.000	0.475	0.520	0.95	0.887
Marital status	0.00	3.857	0.964	−0.725	0.000	0.593	0.640	0.88	0.884
Child care	0.00	4.094	0.908	−0.873	0.000	0.548	0.587	0.83	0.886
Family care	0.00	4.189	0.832	−0.899	0.000	0.510	0.558	0.86	0.887
Family support	0.00	4.213	0.784	−0.850	0.000	0.461	0.503	0.89	0.888
Salary and welfare	0.00	4.291	0.790	−0.981	0.000	0.225	0.117	0.70	0.893
Subsidies	0.00	4.291	0.796	−1.033	0.000	0.244	0.134	0.70	0.892
Repatriation plan	0.00	4.148	0.830	−0.793	0.000	0.318	0.218	0.87	0.891
Possible promotion	0.00	3.801	0.908	−0.516	0.000	0.186	0.102	0.79	0.895
	0.00	2.3–4.4	>0.75	−0.7 – 0.7	<0.05	>0.3	>0.3	>0.7	>0.8

Table 4. Basic Analysis for Demographic Variables

Demographic variables	Type	Sample	Percentage (%)	Negative EW		Positive EW	
				Sample number	Percentage (%)	Sample number	Percentage (%)
Gender	Male	356	86.2	274	77	82	23
	Female	57	13.8	41	72	16	28
Age	≤35	118	28.6	72	61	46	39
	36–50	206	49.9	175	85	31	15
	≥51	89	21.5	68	76	21	24
Education	≤ Senior high school (SHS)	32	7.7	18	56	14	44
	Bachelor	130	31.5	92	71	38	29
	Master	243	58.8	201	83	42	17
	Ph.D.	8	1.9	4	50	4	50
Marital status	Single	113	27.4	62	55	51	45
	Married	298	72.2	251	84	47	16
	Others	2	0.5	2	100	N/A	N/A
Overseas living experience	No	297	71.9	243	82	54	18
	1–5 years	101	24.5	67	66	43	43
	6–10 years	14	3.4	5	36	9	64
	10–15 years	0	N/A	N/A	N/A	N/A	N/A
	15–20 years	0	N/A	N/A	N/A	N/A	N/A
	≥20 years	1	0.24	N/A	N/A	1	100

business in Taiwan. The number of female employees is small, comprising only 13.8% of the total respondents. However, this percentage is close to the typical proportion of female employees in the engineering field in Taiwan. The respondents' ages also displayed a normal distribution. The level of education needed for most engineering consulting occupations is a college degree; 90% of all the respondents have a bachelor's or master's degree. The survey reveals that 71.9% of employees had never lived abroad, and only a few of them (3.6%) had more than five years of experience living abroad.

An advanced analysis of demographic variables is carried out to examine more closely whether the empirical evidence challenges the past viewpoints mentioned in the Introduction. Each value obtained for the mean, standard deviation, *t*-test, and significance is listed in Table 5. It is found that the difference in EW between male employees and female employees does not reach a significant level. This does not agree with the results of Stroh et al. (2000) or Yan et al. (2002). In other words, their findings do not stand, at least for employees working in engineering consulting companies. However, the negative correlation of age to EW holds true for younger employees (<35 years old), who have a significantly higher EW (F value = 13.104), and the trend has a U shape. This specifies that employees aged between 35 and 50 have the lowest EW. After the age of 50, EW increases gradually. Next, the F value for education level is an insignificant influence on employees' EW, which is consistent with previous studies. On the other hand, marital status and overseas living experience are substantially related to EW, which is also consistent with past studies.

Determining and Classifying Impact Factors for EW

Before using RST to determine and classify the impact factors, feature deduction should be performed. Nine tests are suggested: missing value, mean, standard deviation, skewness, t-testing, correlation coefficients, factor loading, measures of sampling adequacy (MSAs), and Cronbach's α. Table 3 exhibits the test results. The thresholds are set according to previous studies (e.g., Chen and Hsu 2008). According to Chen and Hsu (2008), if more than three test results for any factor exceed the thresholds, the factor should be removed. Factor 2, war, thus is deleted. This study applies the RST approach to determine and classify 21 impact factors for EW. Starting with an information system S, let

$$S = \{U, A, V\} \tag{1}$$

where $U = \{x_1, x_2, \ldots, x_N\}$ is defined as the universal set including N objects; $A = \{a_1, a_2, \ldots, a_M\}$ is the attribute set including M objects; and $V = \{v_1, v_2, \ldots, v_k\}$ represents the domain of a values.

Given that objects x and $y \in$ feature X in S are indiscernible from each other, X can be expressed as

$$\text{IND}(X) = \{(x, y) \in U \times U | \forall_a \in X, f_a(x) = f_a(y)\} \tag{2}$$

Let R represent an attribute set. Its lower and upper approximations are defined as

$$\underline{R}(X) = \{x \in U : [x]_{\text{IND}(R)} \subseteq X\} \tag{3}$$

$$\bar{R}(X) = \{x \in U : [x]_{\text{IND}(R)} \cap X \neq \emptyset\} \tag{4}$$

respectively, and

$$X = \begin{cases} \text{rough set}, & \text{if } \underline{R}(X) \neq \bar{R}(X) \\ \text{exact set}, & \text{if } \underline{R}(X) = \bar{R}(X) \end{cases} \tag{5}$$

For all subsets in X, if there is a subset (for example, Q and $Q \subseteq X$) that can represent the same result as X and $\text{IND}(Q) = \text{IND}(X)$, Q is defined as a reduct set of X. The core attributes also can be found based on the set-theoretic intersection of all reducts. The more set-theoretic intersections from reducts, the more important a factor is.

Let $U = 413$ sets, $A = 21$ factors (attributes), and V = domain of each a. The database consisting of 413 sets, with 21 factors in each set, is plugged into Eqs. (1) to (5). Table 6 displays the best results in the positive region (PR) = 1 and stability coefficient (SC) = 1. There are 10 set-theoretic intersections that fit the criteria of PR = 1 and SC = 1. The number of included factors in each set-theoretic intersection is either 11 or 12. The importance classification of these factors is illustrated in Table 7. The importance of the factors is defined based on how frequent a factor appears in all set-theoretic intersections. As a result, three classes of impact level can be identified. Any factor with a frequency ≥90%

Table 5. Advanced Analysis and Comparison for Demographic Variables

Gender	Sample number	Mean	Standard deviation	*t*-test	Significance			
Male	328	2.72	0.98	−0.701	0.483			
Female	55	2.82	1.09					
Levene's test		0.700	Significance		0.497			
Age	Sample number	Mean	Standard deviation	*F* value	Scheffe's significance			
					≤35	35-50	≥51	
≤ 35	118	3.12	1.05	13.104		0.000	0.004	
36-50	206	2.55	0.91				0.673	
≥51	89	2.66	1.00					
Levene's test	1.028	Significance			0.38			
Education	Sample number	Mean	Standard deviation	*F* value	Scheffe's significance			
					≤SHS	Bachelor	Master	Ph.D.
≤SHS	32	2.84	0.954	2.57		0.815	0.959	0.266
University	130	2.65	0.962				0.885	0.067
Master's	243	2.74	1.018					0.106
Doctor	8	3.63	0.744					
Levene's test		1.018	Significance		0.362			
Marital status	Sample number	Mean	Standard deviation	*F* value	Scheffe's significance			
					Single	Married	Others	
Single	113	3.19	1.057	16.861		0.000	0.607	
Married	298	2.57	0.923				0.995	
Others	2	2.50	0.707					
Levene's test		5.832	Significance		0.003			
Overseas living experience	Sample number	Mean	Standard deviation	*F* value	Significance of Dunnett T3 Test			
					None	1–5 years	≥6 years	
None	297	2.60	0.999	14.432		0.000	0.000	
1–5 years	101	3.02	0.894				0.015	
≥6 years	15	3.67	0.724					

(i.e., 9 or 10 occurrence times) is regarded as a core impact factor. Factors 1, 5, 9, 14, 16, and 21 belong to this class. Another class of insignificant impact factors is similarly determined, so it includes anyone with a frequency ≤10%. Five factors are included, 8, 10, 11, 17, and 20. The remaining factors form a medium class containing factors with frequency ≥20% or frequency ≤80%.

Findings and Discussion

Compared to previous studies, the findings obtained in this research provide dissimilarities and similarities for employers in the engineering consulting field. Our study results explicitly state that there is no significant difference in EW between the two genders.

Table 6. Reduct Result

∩ Number	Attribute number	Reducts
1	12	attr1, attr2, attr4, attr5, attr8, attr12, attr1, attr14, attr15, attr17, attr20, attr21
2	11	attr1, attr2, attr4, attr5, attr8, attr12, attr13, attr14, attr15, attr20, attr21
3	11	attr1, attr2, attr4, attr5, attr8, attr11, attr13, attr14, attr15, attr20, attr21
4	12	attr1, attr2, attr4, attr5, attr6, attr8, attr12, attr13, attr14, attr15, attr18, attr20
5	12	attr1, attr3, attr4, attr5, attr8, attr11, attr13, attr14, attr15, attr17, attr20, attr21
6	11	attr1, attr3, attr4, attr5, attr8, attr11, attr13, attr14, attr15, attr20, attr21
7	11	attr1, attr3, attr4, attr5, attr8,attr12, attr13, attr15, attr17, attr20, attr21
8	11	attr1, attr3, attr4, attr6, attr8, attr11, attr12, attr14, attr15, attr17, attr20
9	12	attr1, attr3, attr4, attr6, attr7, attr8, attr13, attr14, attr16, attr15, attr20, attr21
10	12	attr2, attr4, attr6, attr8, attr11, attr12, attr13, attr15, attr17,attr18, attr20, attr21

Table 7. Importance Classification for EW Impact Factors

Factor	Frequency	Percentage (%)	Class
Protest	9	90	A
Local hostility	5	50	B
Social security	5	50	B
Environmental health	10	100	A
Medical standard	7	70	B
Medical accessibility	4	40	B
Expatriation duration	1	10	N
Personal loneliness	10	100	A
Economic development	0	0	N
Price index	0	0	N
GDP	5	50	B
Customs and habits	6	60	B
Religion	10	100	A
Marital status	8	80	B
Child care	10	100	A
Family care	1	10	N
Family support	5	50	B
Salary and welfare	2	20	B
Subsidies	0	0	N
Repatriation plan	10	100	A
Possible promotion	8	80	B

Employers may not allocate expatriation intentionally for candidates aged between 35 and 50. It would take more time and resources to assign them to a foreign region. It might be more feasible to consider candidates that were not in this age group. The findings for education level, marital status, and overseas living experience remain consistent with past results. The impact factors for employees' EW are categorized into three classes that contain six to nine factors. The core impact class reveals an important message for how employers should allocate manpower overseas. For employees, personal safety, heath, sentiment, beliefs, and future career prospects are the top priorities. Expatriate assignments should satisfy such priorities as much as possible to increase the efficiency of project performance. In contrast, employees are relatively less concerned about the economic status of the expatriate region. Subsides and duration of stay also have less effect on EW. This finding should alleviate any misgivings or difficulties in allocating manpower to less developed regions. Family care, however, is classified as having insignificant impact. It is believed that most expatriates are not accompanied by family members. The other factors belong to the medium impact class, most with frequencies reaching 50% or more. The impact degree of possible promotion almost reaches the core impact level. This factor is strongly correlated to the expatriates' future career, ranking it at the top of the medium impact class. The findings may be considered as criteria that may be of benefit to employers for allocating expatriate resources.

At the individual level, employees who expect to have foreign work experience or welcome tackling challenges have reason to believe that they will have more such opportunities between ages 35 and 50. In addition, expatriates may want to ask for more resources from their companies to enhance individual safety and health care before accepting expatriate assignments. Yet, the resources that would be available to them depend on the actual conditions that they encounter. Employees can utilize the results to consider their expatriation willingness more carefully. At the corporate level, less attention paid to personal safety (or even neglect) may be serious enough to jeopardize projects. Misapplying these findings would reduce employees' loyalty, increase unnecessary expenses, and waste time trying to persuade employees with less EW to relocate. Companies that mainly conduct their business abroad also may want to focus on these findings to help them train expatriates, recruit employees, and retain appropriate personnel.

Conclusion

Engineering consulting companies in Taiwan have been expanding worldwide, meaning that they need to be aware of employees' EW. The objective of this study is not only to explore changes of EW in recent decades, but to determine and classify the impact factors. A total of 22 impact factors for employees' international EW are summarized. A survey of the top five engineering consulting firms was conducted. A total of 1,000 questionnaires were distributed, and there were 413 valid respondents out of the total of 486 returned questionnaires. Following nine statistical tests, 1 factor was removed. The RST was used on the remaining 21 factors, yielding three impact level classes: core, medium, and insignificant. Each class is comprised of 5 to 9 factors that influence employees' foreign EW. Therefore, the contribution of this study lies in the identification and determination of EW impact factors for employees working at engineering consulting firms. Construction practitioners can benefit by setting up criteria for expatriate manpower allocation. This could save them time and enable them to target the most appropriate employees for expatriation.

This study does have some limitations. Other valuable data not reflected in the survey of the top five engineering consulting firms could exist. The findings do not fully explain expatriation for those firms that conduct business in other regions such as Europe, Africa, and the United States. It is more practical to carry out an industry-wide survey for all engineering consulting firms that have international expatriation experience. In addition, the survey and its corresponding results are applicable only to engineering consulting firms. They may be a valuable reference for business in general; yet, international manpower allocation may vary from industry to industry. Adjustments would be required before the findings can be applied to real-life cases in industries other than construction. Future studies can focus on the establishment of automation models and the construction of a prediction model using the impact factors and returned questionnaires as the database. Once the demands of prediction inputs and outputs are determined, a prediction model can be created. Such a model also could act as a decision support system. Advanced algorithms may be implemented with the database to assist employers in choosing the proper employees for expatriation. Benefits shown in future studies can be improved in practice.

References

Adler, N. J. (1984). "Expecting international success: Female managers overseas." *Columbia J. World Bus.*, 19(3), 79–85.

Adler, N. J. (1986). "Do MBAs want international careers?" *Int. J. Intercult. Rel.*, 10(3), 277–300.

Adler, N. J. (1991). *International dimensions of organizational behavior*, 2nd Ed., PWS-KENT, Boston.

Al-Subhi Al-Harbi, K. (1997). "Markov analysis of Saudization in engineering companies." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(1997)13:2(87), 87–91.

Aryee, S., Chay, W. Y., and Chew, J. (1996). "An investigation of the willingness of managerial employees to accept an expatriate assignment." *J. Organ. Behav.*, 17(3), 267–283.

Barco, A. (1994). "International expansion, ethics, and prohibited foreign trade practices." *J. Manage. Eng.*, 10.1061/(ASCE)9742-597X(1994)10:5(34), 34–40.

Black, J. S., and Gregersen, H. B. (1991). "Antecedents to cross-cultural adjustment for expatriate in Pacific Rim assignments." *Hum. Relat.*, 44(5), 497–515.

Black, J. S., and Mendenhall, M. E. (1990). "Cross-cultural training effectiveness: A review and theoretical framework for future research." *Acad. Manage. Rev.*, 15(1), 113–136.

Borstorff, P. C., Harris, S. G., Field, H. S., and Giles, W. F. (1997). "Who'll go? A review of factors associated with employee willingness to work overseas." *Hum. Resour. Plann.*, 20(3), 29–40.

Brandenburg, S., Haas, C., and Byrom, K. (2006). "Strategic management of human resources in construction." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(2006)22:2(89), 89–96.

Brandenburg, V., Brandenburg, S., and Beliveau, Y. (2009). "Improving labor-based road rehabilitation in Ghana." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(2009)25:2(87), 87–96.

Brett, J. M., and Reilly, A. H. (1988). "On the road: Predicting the job transfer decision." *J. Appl. Psych.*, 73(4), 614–620.

Brett, J. M., and Stroh, L. K. (1995). "Willing to relocate internationally." *Hum. Resour. Manage.*, 34(3), 405–424.

Brett, J. M., Stroh, L. K., and Reilly, A. H. (1993). "Pulling up roots in the 1990s: Who's willing to relocate?" *J. Organ. Behav.*, 14(1), 49–60.

Chen, J. H., and Hsu, S. C. (2008). "Quantifying impact factor of corporate financing: Engineering consulting firms." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(2008)24:2(96), 96–140.

Comu, S., Unsal, H., and Taylor, J. (2011). "Dual impact of cultural and linguistic diversity on project network performance." *J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000052, 179–187.

Dessler, G. (1998). *Human resource management*, 7th Ed., Prentice-Hall, Upper Saddle River, NJ.
Di Marco, M., Taylor, J., and Alin, P. (2010). "Emergence and role of cultural boundary spanners in global engineering project networks." *J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000019, 123–132.
Feldman, D. C., and Thomas, D. C. (1992). "Career management issues facing expatriates." *J. Int. Bus. Stud.*, 23(2), 271–293.
Gould, S., and Penley, L. E. (1985). "A study of the correlates of the willingness to relocate." *Acad. Manage. J.*, 28(2), 472–478.
Gregersen, H. B., and Black, J. S. (1992). "Antecedents to commitment to parent company and a foreign operation." *Acad. Manage. J.*, 35(1), 65–90.
Grzymala-Busse, D. M., and Grzymala-Busse, J. W. (1995). "The usefulness of a machine learning approach to knowledge acquisition." *Comput. Intell.*, 11(2), 268–279.
Hair, J. F., Jr., Anderson, R. E., Tatham, R. L., and Black, W. C. (1998). *Multivariate data analysis*, Prentice-Hall, Upper Saddle River, NJ.
Han, S., Park, S., Jin, E., Kim, H., and Seong, Y. (2008). "Critical issues and possible solutions for motivating foreign construction workers." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(2008)24:4(217), 217–226.
Harvey, M. G. (1989). "Repatriation of corporate executives: An empirical study." *J. Int. Bus. Stud.*, 20(1), 131–144.
Harvey, M. G., and Buckley, R. M. (1998). "The process for developing an international program for dual-career couples." *Hum. Resour. Manage. Rev.*, 8(1), 457–474.
Hill, C. J., and Tillery, K. R. (1992). "What do male/female perceptions of an international business career suggest about recruitment policies?" *SAM Adv. Manage. J.*, 57(4), 10–14.
Huang, R. C., Mao, I. S., and Lee, H. K. (2010). "Exploring the deterioration factors of RC bridge decks: A rough set approach." *Comput-Aided Civ. Inf.*, 25(7), 517–529.
Kim, Y. M., Kim, C. K., and Lee, J. C. (2009). "Rough set algorithm for crack category determination of reinforced concrete structures." *Adv. Eng. Softw.*, 40(3), 202–211.
Konopaske, R., Robie, C., and Ivancevich, J. M. (2005). "A preliminary model of spouse influence on managerial global assignment willingness." *Int. Hum. Resour. Manage.*, 16(3), 405–426.
Landau, J. C., Shamir, B., and Arthur, M. B., (1992). "Predictors of willingness to relocate for managerial and professional employees." *J. Organ. Behav.*, 13(7), 667–680.
Lin, K. (2011). "Human resource allocation for remote construction projects." *J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000032, 13–20.
Louis, M. R. (1980). "Surprise and sense making: What newcomers experience in entering unfamiliar organization settings." *Admin. Sci. Quart.*, 25(2), 226–251.
Mafakheri, F., Dai, L., Slezak, D., and Nasiri, F. (2007). "Project delivery system selection under uncertainty: Multicriteria multilevel decision aid model." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(2007)23:4(200), 200–206.
Mak, B., and Munakata, T. (2002). "Rule extraction from expert heuristics: A comparative study of rough sets with neural networks and ID3." *Eur. J. Oper. Res.*, 136(1), 212–229.
Mendenhall, M. E., Dunbar, E., and Oddou, G. R. (1987). "Expatriate selection, training and career-pathing: A review and critique." *Hum. Resour. Manage.*, 26(3), 331–345.
Minuchin, S. (1974). *Families and family therapy*, Harvard Univ. Press, Cambridge, MA.
Noe, R. A., Steffy, B. D., and Barber, A. E. (1988). "An investigation of the factors influencing employees' willingness to accept mobility opportunities." *Pers. Psychol.*, 41(3), 559–580.
Pawlak, Z. (1982). "Rough sets." *Int. J. Comput. Inform. Sci.*, 11(5), 341–356.
Pawlak, Z. (2002). "Rough sets, decision algorithms, and Bayes' theorem." *Eur. J. Oper. Res.*, 136(1), 181–189.
Pawlak, Z. (2004). "Decisions rules and flow networks." *Eur. J. Oper. Res.*, 154(1), 184–190.
Richards, D. (1999). "Engineering overseas." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(1999)15:1(24), 24–29.
Richardson, J. (2006). "Self-directed expatriation: Family matters." *Pers. Rev.*, 35(4), 469–486.
Ronen, S. (1989). "Training the international assignees." *Training and development in organizations*, I. L. Goldstein and Associates, Jossey-Bass, San Francisco.
Selmer, J., and De Leon, C. (1989). "Pinoy-style HRM: Human resource management in the Philippines." *Asia Pac. Bus. Rev.*, 8(1), 127–144.
Shaffer, M. A., and Harrison, D. A. (1998). "Expatriates' psychological withdrawal from international assignments: Work, non-work, and family influences." *Pers. Psychol.*, 51(1), 87–118.
Shen, Z., Jensen, W., Berryman, C., and Zhu, Y. (2011). "Comparative study of activity-based construction labor productivity in the United States and China." *J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000037, 116–124.
Shyng, J. Y., Shieh, H. M., Tzeng, G. S., and Hsieh, S. H. (2010). "Using FSBT technique with rough set theory for personal investment portfolio analysis." *Eur. J. Oper. Res.*, 201(2), 601–607.
Stroh, L. K., Varma, A., and Valy-Durbin, S. T. (2000). "Why are woman left at home: Are they unwilling to go on international assignment?" *J. World. Bus.*, 35(3), 241–255.
Takeuchi, R., Tesluk, P. E., Yun, S., and Lepak, D. P., (2005). "An integrative view of international experience." *Acad. Manage. J.*, 48(1), 85–100.
Tasar, M. (2000). "A long-term strategy for Latin America." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(2000)16:6(23), 23–28.
Tung, R. L. (1998). "American expatriates abroad: From neophytes to cosmopolitans." *J. World Bus.*, 33(2), 125–140.
Tung, R. L., and Miller, E. L. (1990). "Managing in the twenty-first century: The need for global orientation." *Manage. Int. Rev.*, 30(1), 5–18.
Veiga, J. F. (1983). "Mobility influences during managerial career stages." *Acad. Manage. J.*, 26(1), 64–85.
Wan, D., Hui, T. K., and Tiang, L. (2003). "Factors affecting Singaporeans' acceptance of international postings." *Pers. Rev.*, 32(6), 711–732.
Xue, X., Shen, Q., and Ren, Z. (2010). "Critical review of collaborative working in construction projects: Business environment and human behaviors." *J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000025, 196–208.
Yan, A., Zhu, G., and Hall, D. T., (2002). "International assignments for career building: A model of agency relationships and psychological contracts." *Acad. Manage. Rev.*, 27(3), 373–391.
Yates, J. (1989). "Training expatriate engineering professionals." *J. Manage. Eng.*, 10.1061/(ASCE)9742-597X(1989)5:3(257), 257–271.
Zhang, Z., and Xu, Z. (2009). "Rough set method to identify key factors affecting precipitation in Lhasa." *Stoch. Env. Res. Risk A.*, 23(8), 1181–1186.
Zhong, N., Dong, J., and Ohsuga, S. (2001). "Using rough set with heuristics for feature selection." *J. Intell. Inf. Syst.*, 16(3), 199–214.