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Power spectral and bispectral study of factors affecting employee turnover

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Abstract: Voluntary employee turnover can cause organizations to lose profits and competitiveness. Unexpected employee turnover may also result in project delay and reduction in project quality. It is important to control employee turnover rate and maintain good employees within an organization. This paper investigates the major causes of voluntary employee turnover in engineering industries. Australia, Mainland China, and Taiwan were selected for the investigation. Questionnaires were administered, and structured interviews were conducted. Power spectrum was used for the analysis. It was found that "Good physical working environment", "Receiving advanced training", and "Short travel distance between home and work" are the major job-related ideal factors for the Australian, Mainland China, and Taiwan respondents, respectively. However, "Far distance between work and home" and "Dislike the colleague relationships" are found as the major factors for leaving jobs for the Australian/Taiwan and Mainland China respondents, respectively. Recommendations to improve and to control employee turnover rate are also discussed.

Keywords: employee turnover, power spectrum, recommendation, engineering, Australia, Mainland China, Taiwan

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1 Introduction

According to the Oxford Dictionary, an employee is a person who works for somebody or for a company in return for wages. It has been noted that employees are money driven. Money-related issues constitute one of the most common reasons for employees voluntarily leaving their jobs (Sigma Assessment Systems 2006).

Employee turnover is defined as the percentage of employees leaving an organization and having to be replaced (Mathis and Jackson 2007). Employee turnover can be divided into two major types: (i) voluntary turnover; and (ii) involuntary turnover. This paper focuses on voluntary employee turnover, which is not controlled by organization managers and can cause unexpected impacts to the organizations.

Organizational performance is related to the economy but, from an employee's point of view, is related to job security (Pullman and Iverson 2000). Job security means the stability of the job environment in an organization (Herzberg 1968). Poor performance of the organization will make employees feel insecure about the jobs, hence increasing the chances of having voluntary turnover (Sigma Assessment Systems 2006).

There are many characteristics in a job that attract people, such as repetitiveness, challenge, danger, perceptions, and job's status (Sigma Assessment Systems 2006). These characteristics can make one job more – or less – attractive than others (Sigma Assessment Systems 2006). Ignoring an employee's good performance, failing to reward an employee, insufficient training, and inappropriate promotion system can lower employees' satisfaction at work, thus raising the intention of voluntary turnover (Sigma Assessment Systems 2006). According to a previous study, age has a negative relationship with voluntary turnover (Rodger et al. 2000). This means that younger employees are more likely to voluntarily leave the jobs than older employees. It was also shown that female employees are less likely to voluntarily leave the job than male employees (Rodger et al. 2000; Aldatmaz et al. 2018; Ozolina-Ozola 2014).

Voluntary turnover can cause financial loss and reduce competitiveness in the organization. Every year, companies spend billions of dollars on recruiting and replacing employees. Replacing an hourly employee can cost a company from US$2,000 to US$11,000, or even US$40,000 if replacing a manager (Stoneman 2006). The total cost of employee turnover for low-complexity jobs is ~US$5,700, and the cost can increase up to US$10,000 for high-complexity jobs (Withiam 2007). In general, the average cost of employee turnover is about one-third of the new hire's annual salary (Michaud 2005; Miodonski 2004).

Getting the right people for the project can highly increase the chances of a project's success. Key employees have knowledge and skills, and they may also be holding confidential information about new products and projects of the company. When key employees leave the company, not only employees with knowledge, but also information and business plans, are lost to competitors. This will highly increase the competitiveness of a company's competitors, putting the company in a low position in the industry (Miodonski 2004).

Research by the Institute of Management and Administrative, USA, showed that the overall voluntary employee turnover rate was ~11.3% in 2004 and it increased to ~14.3% in 2006 (The Institute of Management and Administrative 2003, 2004, 2007). It was also shown that employee turnover rate in the engineering fields was ~24% in 2006.

Voluntary employee turnover is hard to predict and can significantly affect a company; understanding and controlling voluntary employee turnover is very important. To control voluntary employee turnover and maintain good employees for the organizations, organizational leaders and project managers need to understand the causes of employee turnover. Therefore, this paper aims to identify the causes of employee turnover. Australia, Mainland China, and Taiwan were selected for the study. Questionnaire survey and interview discussions were conducted. Power spectrum was used for the analysis. Recommendations to improve the existing employee turnover rate are also discussed.

2 Research methodology

To examine the causes of voluntary employee turnover, a questionnaire survey was conducted. Existing employees in engineering-related organizations constituted the target in this survey. Respondents were asked to provide the significance of each ideal job factor and the factor that induced them to leave their jobs. Australia, Mainland China, and Taiwan were selected for the investigation. The survey was sent to 450 participants with 150 companies from each region; 304 completed responses were received, including 52, 55, and 31 from employees and 44, 81, and 40 from final year students in Australia, Mainland China, and Taiwan, respectively, with an overall response rate of ~67%. However, two of the questionnaires were not properly completed, and thus only 302 questionnaires were valid.

Similar results were previously published (Tam et al. 2016), but only by analyzing the relative importance level. A comparative study will be conducted in the Results section. This paper proposes a novel approach as the analysis method. Power spectrum and bispectrum are used for the analysis in this paper. Before discussing the analysis, details of the power spectrum and bispectrum, as well as the background of Fourier transform, need to be discussed as the power spectrum and bispectrum are based on development from the Fourier transform.

Fourier transform is a useful and powerful tool used to study the "frequency" components of signals and discrete data, which are usually recorded in the time domain. After transforming the data into the frequency domain using the Fourier transform, signal energy distribution at different frequencies is revealed. Effectively, the Fourier transform can be considered a prism by which white light can be split into its individual wavelengths. For the case of the Fourier transform, the signal energy is split over the signal's spectrum, which consists of a number of frequencies at which the frequency components are displayed. Mathematically, the Fourier transform $X(f)$, as a function of the frequency f, is given as follows (Lathi 1998):

$$X(f)=\int_{-\infty}^{+\infty} x(t)e^{-j2\pi ft}\,dt, \quad (1)$$

where $j^2 = -1$ is a complex constant, $\pi \approx 3.1415$, and $x(t)$ is the input signal or data. The input data or signal is usually a 1-D array or a 2-D matrix.

To recover a time signal from its Fourier transform, the inverse Fourier transform is used, which is mathematically given as follows:

$$x(t)=\int_{-\infty}^{+\infty} X(f)e^{+j2\pi ft}\,df. \quad (2)$$

It should be noted that the Fourier transform is a complex number that is uniquely described by its magnitude and phase. Thus, it is clear that there are two ways of representing data: in the time domain; and in the frequency domain using the Fourier transform. The transformation from the time domain to the frequency domain is achieved by using the operator $e^{j\omega t}$, which is given in Equation 3.

$$e^{j\omega t} = \cos(\omega t) + j\sin(\omega t). \quad (3)$$

Frequency is normally defined as the number of repetitions over time, and the concept of "frequency domain" is believed to be new in the field of project management. Frequency is inversely proportional to time, which means that the larger the time, the smaller is the frequency, and vice versa. Using the concept of frequency and time, it can be said that data that have a long time span have densely concentrated spectra over a short frequency range, and vice versa. The magnitude of the frequency components that are displayed over a frequency range or spectrum is defined as being proportional to the signal energy. Signals that are continuous and periodic in time have densely concentrated energy spectra. For ease of understanding, the Fourier transform can be viewed as a mapping of the energy distribution in the signal in the frequency domain at which harmonic peaks or dominant peaks represent the peak energy concentration in the waveform. The concept of peak energy concentration can be analogously considered as dominant peaks in assessing the criteria for employee turnover in surveys. For example, the Fourier transform of a constant signal that is continuous from $-\infty$ to $+\infty$ is an impulse whose energy concentration is theoretically perfect. A common and popular sinusoidal signal of frequency f_0 = 1 Hz has two impulses located at ±1 Hz.

After obtaining the Fourier transform of a signal, it is necessary to estimate its total power or energy, which is given by a power spectrum $P(f)$, as shown in Equation 4

$$P(f) = |X(f)|^2, \quad (4)$$

where $X(f)$ is the Fourier transform of the input signal. It is evident that the power spectrum is proportional to the squared magnitude of the input signal's Fourier transform as expected because the signal energy is directly related to its squared magnitude. It is important to stress that energy plays an important role in determining data characteristics, i.e., periodic, aperiodic, or chaotic; detecting transitions from one state to another, i.e., a transition from periodicity to chaos or from periodicity to transient; and working out the energy weighting at different frequencies (Lathi 1998), which can be achieved by estimating the power spectrum of the input data. In the case of project management, the power spectrum is particularly useful as it can be used to reveal the energy distribution of data points obtained from various surveys. For example, consider a survey consisting of a set of questions that have been distributed to a number of sources to fill out. A person fills out the questions in the survey at any one time, which means that the energy distribution of the person on the various questions in the survey can be estimated using the Fourier transform and the power spectrum under the assumption that the person fills out all of the questions by himself or herself.

By estimating the power spectra of the responses, it is possible to study the energy distribution in each criterion; from that, the criterion with the maximum energy distribution can be considered as the most important or most dominant. In other words, the correlation of various criteria can be revealed using the power spectrum with the phase information being suppressed. The phase information is given by using the bispectral method.

To further study the data, a bispectral method is introduced, which shows the correlation among the criteria at various "frequencies". The bispectrum has been widely used in the field of high-order statistics to study data correlation. The bispectrum $B(f_1, f_2)$ of the input signal in 3-D is given by the following equation (Milligen et al. 1995):

$$B(f_1, f_2) = X(f_1)X(f_2)X^*(f_1 + f_2), \quad (5)$$

where the symbol " * " means complex conjugate.

It is clear that the bispectrum is strongly dependent on the Fourier transform of the input signal. From Equation 5, the term $X^*(f_1 + f_2)$ represents the correlation among the various frequency terms in the $(f_1 + f_2)$ plane. To estimate the bispectrum, the mean value of the data is removed to eliminate sudden spikes and pulses in the bispectrum, which could lead to misleading interpretation. In MATLAB, this can be done by using a detrend(·) function. The Fourier transforms of the detrended data are then calculated; in this case, there are 12 factors for ideal jobs and 12 factors for leaving the jobs, yielding 12 Fourier transforms for ideal job factors and 12 Fourier transforms for leaving the jobs. The bispectrum is then calculated for the data matrix of 112 × 12 for ideal job factors and 112 × 12 for factors for leaving the jobs. For data size of >1,344 columns for ideal job factors and 1,344 columns for factors for leaving the jobs, which is very common in signal processing, substantial computing work is required, which makes the bispectrum sometimes hard to estimate and not practical. However, the bispectrum reveals vital information for the understanding of data characteristics, especially correlation, among various criteria at different frequencies. Similar to the power spectrum that is used to locate dominant criteria in a project management survey, the bispectrum gives the phase information, i.e., the correlation among a number of frequencies, which enables the detailed study of the correlation among the various criteria in the survey. The phase information clearly gives the bispectrum an advantage compared with the power spectrum method. In terms of employee turnover, if the power spectrum can yield efficient evidence on how to determine the most dominant factor(s), then the bispectrum may not be required. However, if organizations require information on how various questions in a survey are related to each other, i.e., whether the responses of some questions may be "predicted" by studying the responses of some specific group of questions, then the bispectrum can be used to reveal this vital information. As a result, the quality of surveys can be significantly improved, yielding an increase in organization's overall performance. The significant advantage of the power spectrum and bispectrum techniques is that these methods can clearly identify the most dominant factor(s) and also "coupling" or correlation phase information, which can be used to study the correlation among various factors in a survey. This can help in improving the survey's quality by removing unnecessary factor(s) and adding more useful factor(s) into it.

After receiving the questionnaire responses, individual structured interviews were arranged with 30 respondents, selected from different countries. The interviews were intended for gathering further comments, elaboration, and interpretation on the results obtained from the questionnaire.

3 Results and discussion

3.1 Factors for an ideal job

Based on previous research (Sigma Assessment Systems 2006; Pullman and Iverson 2000; Rodger et al. 2000; Withiam 2007; Michaud 2005; Miodonski 2004; The Institute of Management and Administrative 2003, 2004, 2007; Chiles 2005; HRFocus 2005; Kratcoski 2005; Richardson 2006; Wanous 1975), 12 ideal job factors were used for this survey. The factors include (i) high salary; (ii) like the job nature; (iii) learn new things; (iv) receiving advanced training; (v) good physical working environment; (vi) good colleague working environment; (vii) able to get promotion; (viii) more holidays; (ix) regular working time; (x) short travel distance between home and work; (xi) less work pressure; and (xii) company business doing well.

From previous work (Lathi 1998), it was found that "short travel distance between home and work" and "less work pressure" are the major ideal factors in general, while "short travel distance between home and work" was found to be the major factor for Australia and Taiwan. Table 1 shows the power spectrum magnitudes and rankings of the ideal job factors from the survey. This study has found similar results for "Short travel distance between home and work", being the most important ideal job factor for the Taiwan respondents and the third for the Mainland China respondents; however, it is ranked as the last for the Australian respondents. From the interview discussions, interviewees from Mainland China and Taiwan explained that most of them are family oriented. It is also because of the one-child policy in Mainland China, noted by another interviewee. It is common to find three or four generations living under the same roof in Mainland China and Taiwan. However, the Australia culture is different from this. It is common to find Australian youngsters moving to other states because of work, or even during their degree studies. The Australian interviewees argued that they consider the working environment, learning curve, and colleague relationships as the major criteria. Therefore, "Good physical environment", "Learn new things", and "Good colleague working environment" are the top three factors for ideal jobs, with the power spectrum magnitudes of about 1.377, 1.2383, and 1.1883, respectively, for the Australian respondents.

"Receiving advanced training" was found to be the most important factor for an ideal job, with the power spectrum magnitude of about 3.3709 for the Mainland China respondents in the survey. The interviewees highlighted that training is an important part of their learning, particularly in the competitive environments in, for instance, Mainland China. Most of the employees in Mainland China are quite passionate about their jobs. They are ready to use their knowledge from the university and their past experience in practices and to learn from that. The interviewees also noted that Chinese employees are commonly recognized as hard working.

The Mainland China respondents did not consider "High salary" as an ideal job factor, which was ranked the least in the survey, with the power spectrum magnitude of ~1.3637. During the interview discussions, the interviewees highlighted that salaries in Mainland China are standard in engineering jobs. The salary package even has some regular bonus for their jobs, as noted by an interviewee. Therefore, it is not important for them to look at the salary for their ideal jobs. Alternatively, the interviewees noted that the physical working environment is their main concern for an ideal job, in which most of the fresh graduates can only find on-site jobs. The graduates prefer to work in an office, rather than on site. It is very common in Mainland China that working in polluted environments can cause serious illness in the long term, including musculoskeletal disorders and pneumoconiosis.

Tab. 1: Power spectrum magnitudes and rankings for the ideal job factors.

Factors	Australia		Mainland China		Taiwan	
	Power spectrum magnitudes	Rankings	Power spectrum magnitudes	Rankings	Power spectrum magnitudes	Rankings
High salary	1.0077	5	1.3637	12	1.2445	7
Like the job nature	0.6389	11	2.6729	5	1.5695	2
Learn new things	1.2383	2	2.2984	9	1.4537	5
Receiving advanced training	0.9913	6	3.3709	1	1.2341	8
Good physical working environment	1.3770	1	2.0146	10	1.0433	11
Good colleague working environment	1.1883	3	1.7010	11	1.1692	9
Able to get promotion	1.1609	4	2.9596	4	0.8772	12
More holidays	0.6455	10	3.1567	2	1.4626	4
Regular working time	0.8377	9	2.3675	7	1.2575	6
Short travel distance between home and work	0.5696	12	3.1389	3	1.7344	1
Less work pressure	0.9242	8	2.3012	8	1.4751	3
Company business doing well	0.9649	7	2.3964	6	1.0716	10

Tab. 2: Power spectrum magnitudes and rankings for factors on leaving the jobs.

Factors	Australia		Mainland China		Taiwan	
	Power spectrum magnitudes	Rankings	Power spectrum magnitudes	Rankings	Power spectrum magnitudes	Rankings
Low salary	0.9696	7	2.6148	10	1.0030	10
Do not like the job nature	1.2627	3	2.2332	12	1.4118	5
Cannot learn new things	1.0230	6	2.4785	11	1.2904	7
Cannot provide advanced training	1.2898	2	3.4002	2	1.3006	6
Dislike the physical working environment	0.7760	9	3.3031	3	1.2883	8
Dislike the colleague relationships	0.6552	12	4.1591	1	0.9356	11
Cannot get promotion	0.9509	8	3.2070	5	1.2477	9
Fewer holidays	0.7063	11	2.6925	8	1.4928	4
Overtime working	0.7297	10	3.2721	4	0.8841	12
Far distance between work and home	1.3478	1	2.8273	6	1.8376	1
High working pressure	1.1373	5	2.6627	9	1.6973	2
Company business goes down	1.2358	4	2.7693	7	1.5598	3

3.2 Factors for leaving the jobs

Based on previous research (Sigma Assessment Systems 2006; Pullman and Iverson 2000; Rodger et al. 2000; Withiam 2007; Michaud 2005; Miodonski 2004; The Institute of Management and Administrative 2003, 2004, 2007; Chiles 2005; HRFocus 2005; Kratcoski 2005; Richardson 2006; Wanous 1975), there are 12 factors for leaving the jobs, which are used for this survey. These include (i) Low salary; (ii) Do not like the job nature; (iii) Cannot learn new things; (iv) Cannot provide advanced training; (v) Dislike the physical working environment; (vi) Dislike the colleague relationships; (vii) Cannot get promotion; (viii) Fewer holidays; (ix) Overtime working; (x) Far distance between work and home; (xi) High working pressure; and (xii) Company business goes down.

From the previous work of Lathi (1998), it was found that "less work pressure" was found to be important for respondents in Mainland China. "Overtime working" was found to be the major factor for leaving the jobs in general and for Taiwan, while "fewer holidays" was the factor for Australia and "high working pressure" was found for Mainland China. Table 2 shows the power spectrum magnitudes and rankings of the factors for leaving the jobs obtained from the survey. The results are significantly different from the previous results. "Far distance between work and home" is ranked as the most important factor for leaving the jobs for the Australian and Taiwan respondents, with the power spectrum magnitudes of about 1.3478 and 1.8376, respectively. The argument for the Taiwan respondents is similar as in the previous section, as they are family oriented, by which they prefer to live close to their families. However, an interesting result is found for the Australian respondents. From the results in the previous section on the ideal job factors, the Australian respondents did not view “short distance between work and home” as the ideal job factor. However, if “far distance between work and home” becomes applicable, the Australian respondents considered it as the most important factor. From the interview discussions, the interviewees explained that the arguments arising from this sentence are a bit different. They noted that it is not a problem for them to move and relocate because of jobs. However, far distances, such as remote locations or the outback, were not favorable to them for continuously working. The main problems are that there are limited resources, such as hospitals and social welfares, in the remote locations.

“Dislike the colleague relationships” was considered the most important factor for leaving the jobs, with the power spectrum magnitude of about 4.1591 for the Mainland China respondents in the survey; however, it was ranked as the least and second least for the Australian and Taiwan respondents, respectively. The interviewees explained that working relationships with colleagues is an important factor for the success of a whole project. Particularly for engineering projects, it is always teamwork, rather than an individual’s efforts, which can finish the whole project. There is thus no doubt that good colleague relationships can help bring in the success of a project for the whole team. However, the roles of each party are clearly distinguished, particular in Australia and Taiwan; as long as individual parties provide good support for the projects, their performance will be recognized. This explains the relatively low rankings collected from the Australian and Taiwan respondents.

From Figure 1 and Figure 2, the bispectra of the Australian and China respondents show the distribution peaks at almost every response frequency, which indicates that the indicators are quite independent and random. From Figure 3, the bispectrum of the Taiwan indicators shows distributive peaks, which suggests that the responses are periodic and thus somewhat dependent on each other. From the bispectra of Australia, China, and Taiwan of the ideal job factors, it can be suggested that (1) finding jobs in Australia and China appears to be fairer and less subjective than in Taiwan; (2) the Taiwanese industry has certain criteria and expectations from graduates and job-seekers. If they do not meet those requirements, it is not possible for them to find an alternative way to find jobs, even though their qualifications may be equivalent to the required criteria.

From Figure 4, the bispectrum of the factors affecting leaving jobs is quite similar to that of ideal job factors seen in Figure 1. In addition, sharper peaks are present in Figure 4, compared to those in Figure 1, which means that the reasons for leaving jobs are subjective. This fact can also be clearly observed by comparing Figure 2 and

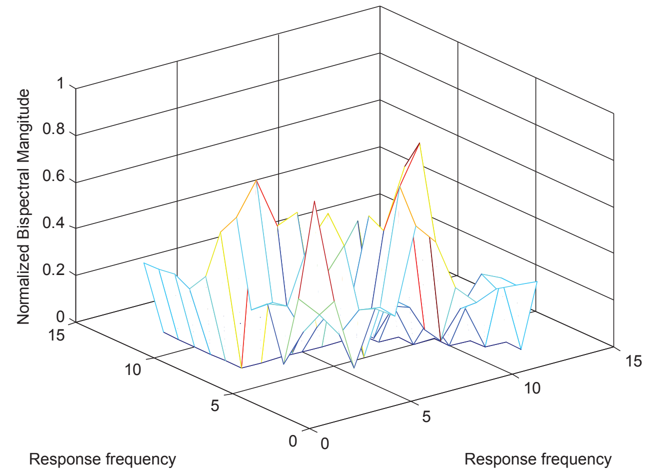

Fig. 1: Bispectrum for ideal job factors in Australia.

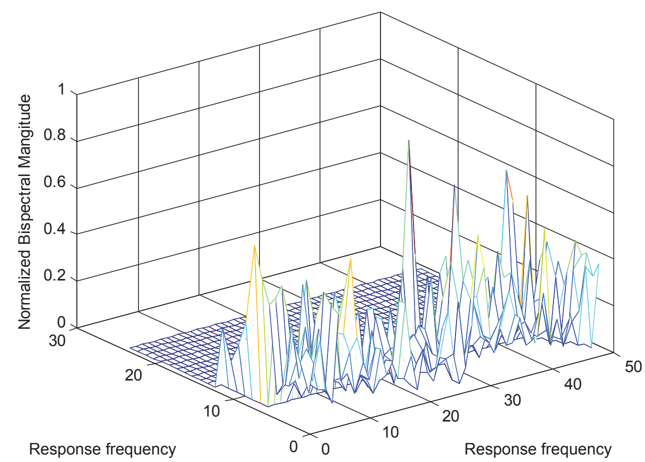

Fig. 2: Bispectrum for ideal job factors in Mainland China.

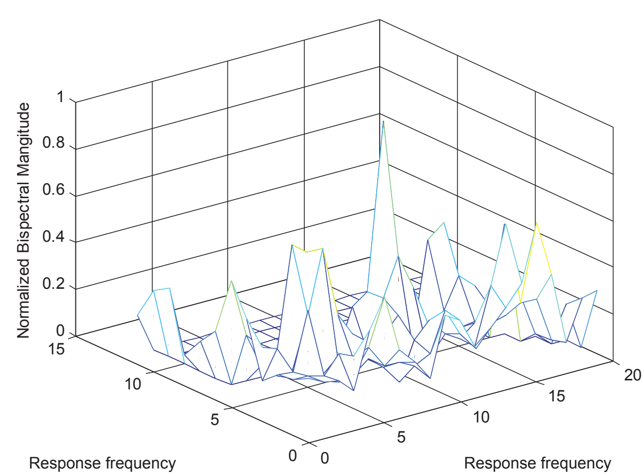

Fig. 3: Bispectrum for ideal job factors in Taiwan.

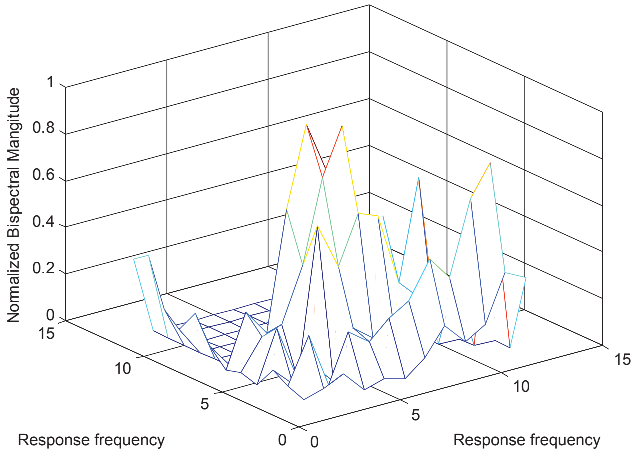

Fig. 4: Bispectrum for factors for leaving the jobs in Australia.

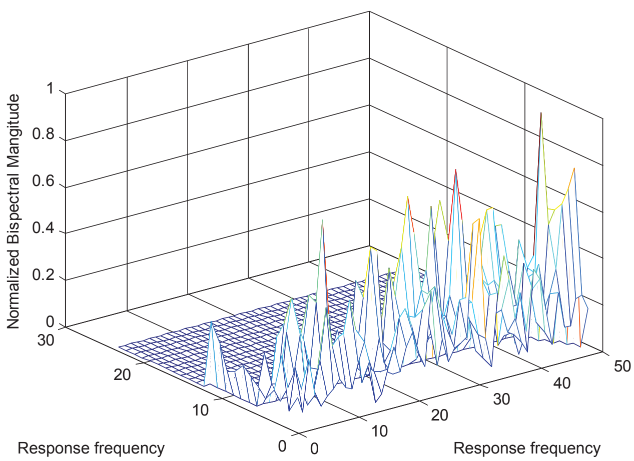

Fig. 5: Bispectrum for factors for leaving the jobs in Mainland China.

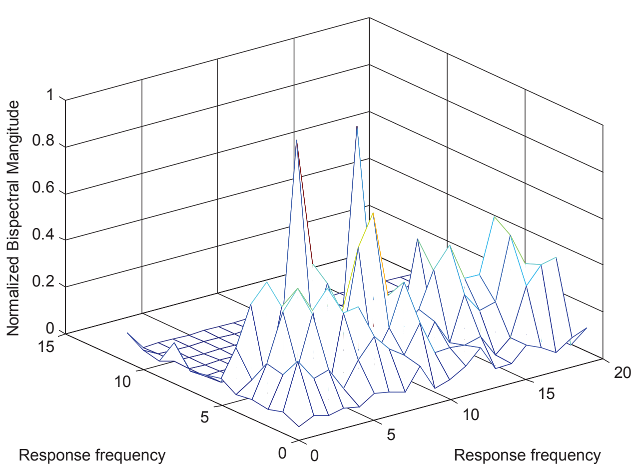

Fig. 6: Bispectrum for factors for leaving the jobs in Taiwan.

Figure 5, as well as Figure 3 and Figure 6. Further, from Figure 2 and Figure 5, the reasons for leaving jobs in China are more subjective than those in Australia and Taiwan because of periodic sharp bispectral peaks.

4 Recommendations

Based on the interview discussions, the following recommendations are suggested to reduce voluntary employee turnover rates:

- Providing necessary training for employees for enriching knowledge and for facilitating possible promotion;
- Providing pay rise each year with at least matching local inflation rates;
- Providing social activities for employees for improving colleague relationships;
- Regularly communicating with employees and involving them in decision-makings; and
- Regularly updating employees about organizational performance and future directions.

5 Conclusion

This paper investigated the causes for voluntary employee turnover. Australia, Mainland China, and Taiwan were selected for this paper. Questionnaires were administered, and structured interviews were conducted. Power spectrum was used for the analysis. It was found that “Good physical working environment”, “Receiving advanced training”, and “Short travel distance between home and work” were the major job-related ideal factors for the Australian, Mainland China, and Taiwan respondents, respectively. However, “Far distance between work and home” and “Dislike the colleague relationships” were found as the major factors for leaving the jobs for the Australian/Taiwan and Mainland China respondents, respectively. Recommendations to improve voluntary employee turnover are provided.

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