International Journal of Industrial Ergonomics 54 (2016) 73–82

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

A manufacturing-oriented model for evaluating the satisfaction of workers – Evidence from Turkey

Omer Ozturkoglu [a], Ebru E. Saygılı [b], Yucel Ozturkoglu [c, *]

[a] Department of Industrial Engineering, Yasar University, Izmir, Turkey
[b] Department of International Trade and Finance, Yasar University, Izmir, Turkey
[c] Department of International Logistics Management, Yasar University, Izmir, Turkey

ARTICLE INFO

Article history:
Received 13 November 2014
Received in revised form
9 April 2016
Accepted 9 May 2016
Available online 21 May 2016

Keywords:
Job satisfaction
Ergonomics
Manufacturing
Auto industry
Safety

ABSTRACT

Job satisfaction, in terms of worker's satisfaction, is one of the intensively studied areas in human resource and management. However, there is little information available on how ergonomics and the manufacturing environment affect job satisfaction. This study analyzes the extent of the relationship between job satisfaction and work and workplace related conditions. A conceptual model is proposed to evaluate job satisfaction that considers 34 elements in four categories: manufacturing systems, facility design, safety and ergonomics, and human resources and management. A survey of 169 blue-collar workers working in the automotive industry was conducted to investigate the applicability of the model. A comprehensive exploratory factor analysis was used to determine inter-related elements, their underlying factors and their effects on job satisfaction. The analysis revealed 6 factors with 18 related elements. From a multi linear regression analysis, we develop a job satisfaction model built on factors of human resource policies, safety, ergonomics, air quality, thermal comfort and disturbing equipment. The results reveal that ergonomics plays the most important role in workers' satisfaction for the respondent Turkish automotive workers. In contrast, human resource policies seem not play a critical role in job satisfaction because of higher standards in automotive industry compared to other industries in Turkey.

1. Introduction

Job satisfaction is described as a person's overall effective reaction to the set of work and work-related elements (Cranny et al., 1992). Because job satisfaction is one of the determinants of employee turnover (Mobley et al., 1979; Griffeth et al., 2000), it has been of interest for decades to industrial managers and researchers. Employee turnover is a problem for companies not only because they incur high costs (replacement, hiring, training costs, etc.) but also because of loss of institutional knowledge. Nowadays, companies are also dealing with the high costs of turnover of Gen-Y workers because, it is claimed, 70% of them quit their first job within two years of joining the organization (Schawbel, 2011). Several previous studies have also demonstrated a negative correlation between job satisfaction and intention to quit the job (MacIntosh and Doherty, 2010; Egan et al., 2004). Thus, job satisfaction, in the context of employee retention and turnover, is important for companies aiming to gain a competitive advantage in the market.

Various factors affect job satisfaction. The main factors considered in the literature are psychological, human resources, physical workplace and physical risk. Because psychological factors are hard to analyze, requiring specialist psychological knowledge and research methods, they are not considered within the scope of this study.

Human resources and management policies are an extensively studied field in job satisfaction. Many job satisfaction elements related to such policies have been defined, analyzed and classified since early studies. Smith et al. (1969) was a pioneering study focusing on job satisfaction elements related to human resource policies. The authors introduced the Job Descriptive Index (JDI) to develop a structure for job satisfaction evaluation. This index consists of five scales related to worker satisfaction, such as work, pay, promotion, co-workers and supervision. Sims et al. (1976) developed a six-dimensional model of variety, autonomy, feedback, dealing with others, task identity and friendship opportunities.

* Corresponding author.
E-mail addresses: omer.ozturkoglu@yasar.edu.tr (O. Ozturkoglu), ebru.esendemir@yasar.edu.tr (E.E. Saygılı), yucel.ozturkoglu@yasar.edu.tr (Y. Ozturkoglu).

http://dx.doi.org/10.1016/j.ergon.2016.05.002
0169-8141/

Røssberg et al., (2004) introduced the ten-item working environment scale (WES-10), including workload, conflict, self-realization and nervousness, and investigated the relationship of WES-10 scores with job satisfaction.

Other key elements related to human resource management are job complexity and pay (Gerhart, 1987), regular payment (Bilgiç, 1998), teamwork and supervisor support (Griffin et al., 2001), job specificity, routineness, feedback, and human resource development (Wright and Davis, 2003), flexible workplace practices (Bauer, 2004), pay, continuing education, professional growth and work environment (Randolph, 2004), payment, supervision, promotion, working hours and co-workership (Abdullah et al., 2007).

Job satisfaction is related to elements concerning the physical work place and physical risk, such as physical conditions or availability of tools, equipment and furnishings. Cleanliness of the workplace, the condition and availability of furnishings and office equipment, basic facilities and even the color of the work place are a few examples of this category. Physical risk elements include all potential factors related to occupational health and safety, and ergonomics. The most commonly studied elements in these two categories are listed in Table 1. The effects of the elements in Table 1 on job satisfaction are discussed briefly below.

Dawal and Taha (2006) surveyed automotive industry workers to investigate the effects of several environmental factors and job characteristics on job satisfaction, such as skill variety, autonomy and feedback. They concluded that there is a positive correlation between job satisfaction and environmental factors. Abdullah et al. (2007) conducted factor and regression analyses to determine the significance of the relationship between work environment elements and job satisfaction, finding that cleanliness, communication, use of equipment and basic facilities each have a significant impact on job satisfaction. Lee and Guerin (2009) introduced seven indoor environment quality (IEQ) criteria in relation to job satisfaction and work performance. They found that, while furnishing quality has a significant impact on job satisfaction and work performance, indoor air quality only affects work performance. Similarly, Newsham et al. (2009) explored the relationship between environmental elements and job satisfaction, finding that lighting has a major impact on job satisfaction. Ardakani et al. (2013) presented a strong relationship between job satisfaction and physical conditions in a manufacturing industry while Fairbrother and Warn (2003) reported that the physical aspects of workplace did not predict job satisfaction in a navy warship.

Ergonomics, human factors and physical risk elements have been found to affect labor performance, labor productivity and worker satisfaction (Shikdar and Sawaqued, 2003). A lack of ergonomic and safety principles are two main sources of risks in a manufacturing environment that may cause injuries, emotional or physical stress, reduced motivation and dissatisfaction, and low productivity (http://www.sciencedirect.com/science/article/pii/S0360835203000743Ayoub, 1990a, 1990bhttp://www.sciencedirect.com/science/article/pii/S0360835203000743). The 5th European Working Conditions Survey classified physical risks as vibrations, noise, high temperatures, low temperatures, dust, chemical substances, tiring or painful positions, heavy loads, and repetitive hand or arm movements (Eurofound, 2012). Kittusamy and Buchholz (2004) also concluded that whole body-vibration and non-neutral body postures are two important risk elements for operating engineers. From examining the relationship between physical work environment and long-term sickness absence among Danish employees, Lund et al. (2006) reported that uncomfortable working positions, lifting or carrying loads, and pushing or pulling loads increase the risk of long-term sickness absence among both female and male employees. For female employees, the negative effects of poor physical work conditions increase as psychosocial work conditions get worse. Kahya (2007) also found that poor workplace conditions, such as physical effort, environmental conditions and hazards, had a negative impact on employee performance.

From an in-depth analysis of previous research, this study develops a comprehensive list of job satisfaction elements, aiming to present a holistic view of the job satisfaction problem in contrast to the literature, in which most studies focused only on a few major aspects. As well as considering many previously emphasized job satisfaction elements, we introduce additional elements focusing on ergonomics, safety and manufacturing environment, which have been ignored in previous studies. We aim to offer insights to industry by explaining the importance of the relationships between these elements and job satisfaction. We especially emphasize ergonomics and safety in our analysis because Eurofound (2012) revealed that European workers have seen no reduction in their levels of exposure to physical risks since 1991. Indeed, levels of “tiring and painful positions” and “repetitive hand or arm movements” risks have increased. According to these survey results,

Table 1
Comprehensive list of job satisfaction elements.

Environmental job satisfaction elements	Author(s)
Basic facilities: toilet/restroom, canteen, prayer room, daycare, parking, etc.	Martel and Dupuis (2006), Abdullah et al. (2007)
Equipment usage/ergonomics/posture	Abdullah et al. (2007); Martel and Dupuis (2006); Synwoldt and Gellerstedt (2003); Kittusamy and Buchholz (2004); Lund et al. (2006); Marras et al. (2000)
Physical effort and risk factors (lifting, pushing, pulling, bending, etc.)	Kahya (2007); Lund et al. (2006); Marras et al. (2000)
Dust	Kahya (2007); Shikdar and Sawaqued (2003)
Heat/temperature/thermal comfort	Kahya (2007); Dawal and Taha (2006); Shikdar and Sawaqued (2003); Lee and Guerin (2009); Turcotte (1988)
Noise	Abdullah et al. (2007); Kahya (2007); Dawal and Taha (2006); Shikdar and Sawaqued (2003); Martel and Dupuis (2006); Synwoldt and Gellerstedt (2003); Turcotte (1988)
Smell	Kahya (2007)
Light	Kahya (2007); Dawal and Taha (2006); Shikdar and Sawaqued (2003); Martel and Dupuis (2006); Synwoldt and Gellerstedt (2003); Lee and Guerin (2009); Newsham et al. (2009); Turcotte (1988)
Humidity	Kahya (2007); Dawal and Taha (2006); Turcotte (1988)
Air quality/ventilation	Abdullah et al. (2007); Lee and Guerin (2009); Newsham et al. (2009)
Maintenance	Lee and Guerin (2009)
Vibration	Synwoldt and Gellerstedt (2003); Kittusamy and Buchholz (2004); Turcotte (1988)
Acoustics	Lee and Guerin (2009); Newsham et al. (2009)
Cleanliness	Abdullah et al. (2007); Lee and Guerin (2009); Martel and Dupuis (2006)
Office furnishings	Lee and Guerin (2009); Carlopio and Gardner (1992); Newsham et al. (2009); Synwoldt and Gellerstedt (2003)
Office layout	Lee and Guerin (2009)

because Turkish workers have the fourth and third highest levels of exposure to posture-related risks and ambient risks, respectively (Eurofound, 2012), we surveyed the Turkish automotive manufacturing industry to evaluate our conceptual model. We also chose this industry because labor wages, workplace environment, quality standards and human resource management policies are slightly better than other traditional industries, such as textiles and food, because of similar standards imposed by international automotive companies across all the companies in the Turkish automotive industry.

The rest of the paper is organized as follows. The next section presents the research framework and methodology. The results section reports the exploratory factor analysis conducted on the collected data, and the regression model developed to show the relationship of various factors with worker satisfaction. The paper concludes with a discussion of the main findings, and insights for industry practice about critical elements to improve worker satisfaction.

2. Research methodology

The main aim of his study is to examine the potential influence of job satisfaction elements on blue-collar worker job satisfaction in a manufacturing environment. We also aim to investigate the relationships among these elements to develop a model for evaluating individual workers' satisfaction levels. This study contributes to research by providing a comprehensive list of potential job satisfaction elements and practical insights by identifying the most influential elements on job satisfaction.

From the elements discussed in the previous section and introducing new elements, we compiled a comprehensive list of potential job satisfaction elements, presented in Table 2.

We propose a new conceptual model of job satisfaction, which we developed by categorizing the elements in a different way to the literature in order to emphasize elements related to ergonomics, safety and manufacturing environment. As seen in Fig. 1, these elements are classified into four categories, which we assume are the principal determinants of job satisfaction, encompassing the relevant elements listed below each one. This study investigates the effects of these factors on job satisfaction using exploratory factor analysis. In Fig. 2, the study's methodology is outlined to investigate whether these potential factors affect manufacturing workers' satisfaction or not. This methodology is also intended to enable us to explore which groups of elements are strongly inter-related.

To investigate the critical underlying factors for job satisfaction, we tested our proposed model by conducting a survey. The survey was divided into two sections. The first part had seven questions concerning the demographic profile of the manufacturing workers. The second part included questions measuring the relationships between selected elements and worker satisfaction. These questions were not designed to identify the workers' job satisfaction levels. Rather, they were designed to measure how much importance workers give to these elements to be satisfied in their jobs. Hence, one question for each selected element was provided.

The study was carried out in the third largest production area in western Turkey, sampling companies working in the Organized Industry Zone located in Izmir, Turkey's third largest city. Data was collected from automotive spare part manufacturers using a random sampling technique. A self-administered questionnaire was developed and distributed via email to ten different manufacturing companies, targeting respondents working in the manufacturing environment (workshops) of each company. A five-point Likert scale was used with different wordings appropriate to specific questions, such as agree-disagree or low-high. The questionnaires were completed voluntarily by all respondents. From the target sample of 185 questionnaires, 169 completed questionnaires were returned. The collected data was analyzed using IBM SPSS Statistics 20 for Windows.

As depicted in Fig. 2, exploratory factor analysis (EFA) was conducted to analyze the collected data and extract significant and meaningful factors. The first two steps are data collection steps in accordance with predetermined elements. The third step represents a preliminary analysis of data, in which correlation and anti-image correlation matrices are scanned, and Kaiser-Meyer-Olkin (KMO) and Bartlett's Test statistics are calculated. In the fourth step, factor extraction is performed to reveal the significant factors. For interpretation of the dependency of the extracted factors, rotation of component matrix and factor loading analysis were performed in the fifth step. The sixth step verified the internal consistency of the determined principal factors. The final step generated an equation to estimate workers' job satisfaction with respect to the determined factors.

2.1. Descriptive statistics

The descriptive analysis, based on 169 valid questionnaires, provides the demographic background of the participants, as presented in Table 3. Most respondents were male (150) with only a few females (9). Nearly half (49%) were aged between 25 and 35, and very few above 45. 68% of the respondents had more than 3

Table 2
Potential job satisfaction elements considered in the study.

No	Elements	No	Elements
E1	Age of the available machines	E18	Basic facilities of the company (such as cafe, nursery, etc.)
E2	Frequency of overtime working	E19	Acoustics of the working area
E3	Frequency of lifting heavy loads	E20	Humidity of the working area
E4	Job security	E21	Dust of the working area
E5	Flexibility of working hours	E22	Ventilation of the working area
E6	Painful positions	E23	Availability of safety applications in the working area
E7	Schedule of break and rest times	E24	Outfit of workers
E8	Noise of the working area	E25	Need or usage of special apparatus
E9	Salary	E26	Promotion
E10	Vibration of the working area	E27	Shuttle to the facility
E11	Quality of lunches	E28	Light in the working area
E12	Support of good posture	E29	Smell of the working area
E13	Supervision	E30	Temperature of the working area
E14	Repetitive movements	E31	Laceration risk
E15	Regular maintenance of the machines	E32	Cleanliness of the working area
E16	Risk of contracting dangerous materials in the working area	E33	Standing and squatting
E17	Layout of the working area	E34	Availability of required tools

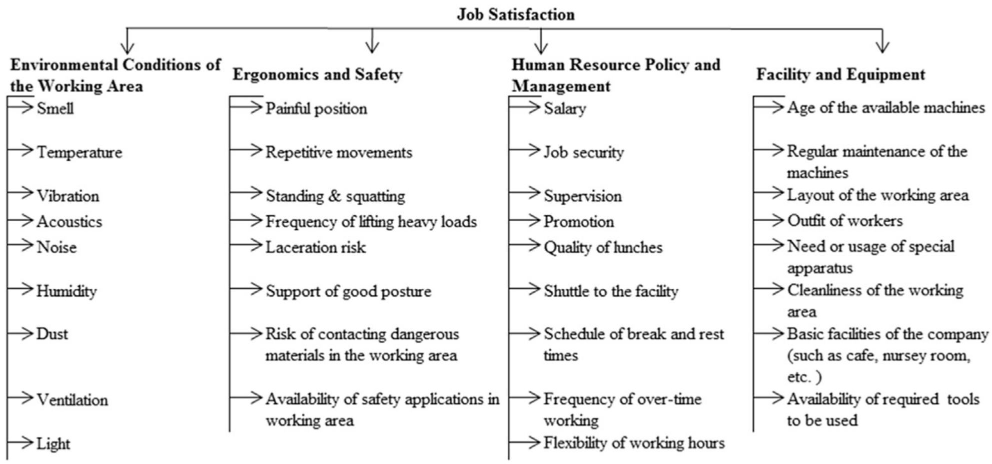

Fig. 1. Proposed conceptual framework for the main job satisfaction factors and their elements.

years working experience. Slightly over half the workers were married (58.6%). Finally, 78% of the workers had a vocational school degree or higher. A Normality test, using a 95% confidence interval, was conducted to see if the preliminary data set was normally distributed or not. The test showed that the data was not normally distributed, as confirmed by skewness and kurtosis values.

2.2. Factorability test

Before performing a factor analysis, the adequacy of the correlation matrix of the collected sample was assessed first. Tabachnick and Fidell (2012) argued that a factor analysis is most likely redundant if no correlation exceeds 0.3. The correlation matrix for the current data contained high correlations, indicating that a factor analysis was justified. However, in the anti-image matrix, which is the matrix of the negatives of the partial correlations among elements, several of the diagonal values, which are individual KMO Measure of Sampling Adequacy values, were lower than 0.5. This shows that several elements appear to lack sufficient correlation with other elements; hence, they should be removed (Hair et al., 2006). Accordingly, elements with the lowest KMO values were removed one by one, starting from the lowest value following the factorability test in Fig. 2. These elements are listed in Table 4, along with their KMO values.

Finally, the general Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy test was analyzed to predict if the data was likely to factor well, based on the correlations. Using SPSS, a KMO value of 0.607 was obtained, which indicates that the common variance bordered on mediocre according to Marshall and Olkin (1974). That is, the factors appear to have a fair but not substantial amount of variance. This indicated that a factor analysis was justified of the number of main factors might be fewer than the originally proposed set. Hence, a factor analysis was performed to explain the remaining 26 elements in terms of fewer principal factors.

Bartlett's test of sphericity was also analyzed for the remaining 26 elements to determine the factorability of an inter-correlation matrix among factors (Bartlett, 1950). The result indicated that the data set was appropriate for factor analysis because it came from a multivariate normal distribution (significance level was 0.000 where $p < 0.05$) (Tabachnick and Fidell, 2012). In other words, the sample inter-correlation matrix did not come from a population in which the inter-correlation matrix is an identity matrix. The results are given in Table 5. In short, both Bartlett's test of sphericity and the KMO measure of sampling adequacy show that inter-correlation matrix is factorable.

2.3. Exploratory factor analysis

In the first round of the factor analysis, 26 elements were examined using the Principal Component Extraction method. Communality values of all elements, given in Table A1 in the Appendix, were greater than the 0.5 as suggested by Field (2013). There should be as many components (eigenvectors) as there are elements in the analysis. However, most may be unimportant because of their relative contribution to explaining the total variance. Hence, in the first part of the factor extraction, 8 independent underlying components (or factors) were identified, explaining 71.1% of the total variance (see Table A2 in the Appendix). Each component had an eigenvalue (EV) of at least 1, which means that these components are stable according to Kaiser's criterion (EV > 1) (Kaiser, 1970, 1974). The scree plot, given in Fig. A1 in the Appendix, supported this finding, as the plot decreased sharply after the eighth component. In the next step, the component matrix was rotated using orthogonal rotation (varimax) to analyze uncorrelated components. The matrix shows the component loadings for each element onto each component (see Table A3 in the Appendix). Element 2 was removed because component's loading was less than 0.5 (0.454) in the rotated component matrix. The factor analysis was then re-conducted (Kline, 2014), with the iterations performed according to the methodology in Fig. 2. This process eliminated elements 11, 16, 25, 24, 34, 28, and 1 because they either loaded too weakly on one component (<0.5) or cross-loaded strongly on more than one component. This left 18 elements with a KMO measure of sampling adequacy value of 0.652, which improved on the initial test value. The resulting factor analysis revealed 6 underlying components, explaining 71% of the total variance (see Table 6), which was supported by the new scree plot (see Fig. A2 in the Appendix). A final rotation of the component matrix enabled all elements to have strong loadings on only one factor with each factor including more than one element (see Table A4 in the Appendix).

3. Results

The analysis reveals that 18 elements with an underlying 6 components have a significant impact on the job satisfaction of the workers who participated in the survey. Based on the elements loaded under them, we labeled these components, called factors hereafter, ergonomics, disturbing equipment, thermal comfort, air

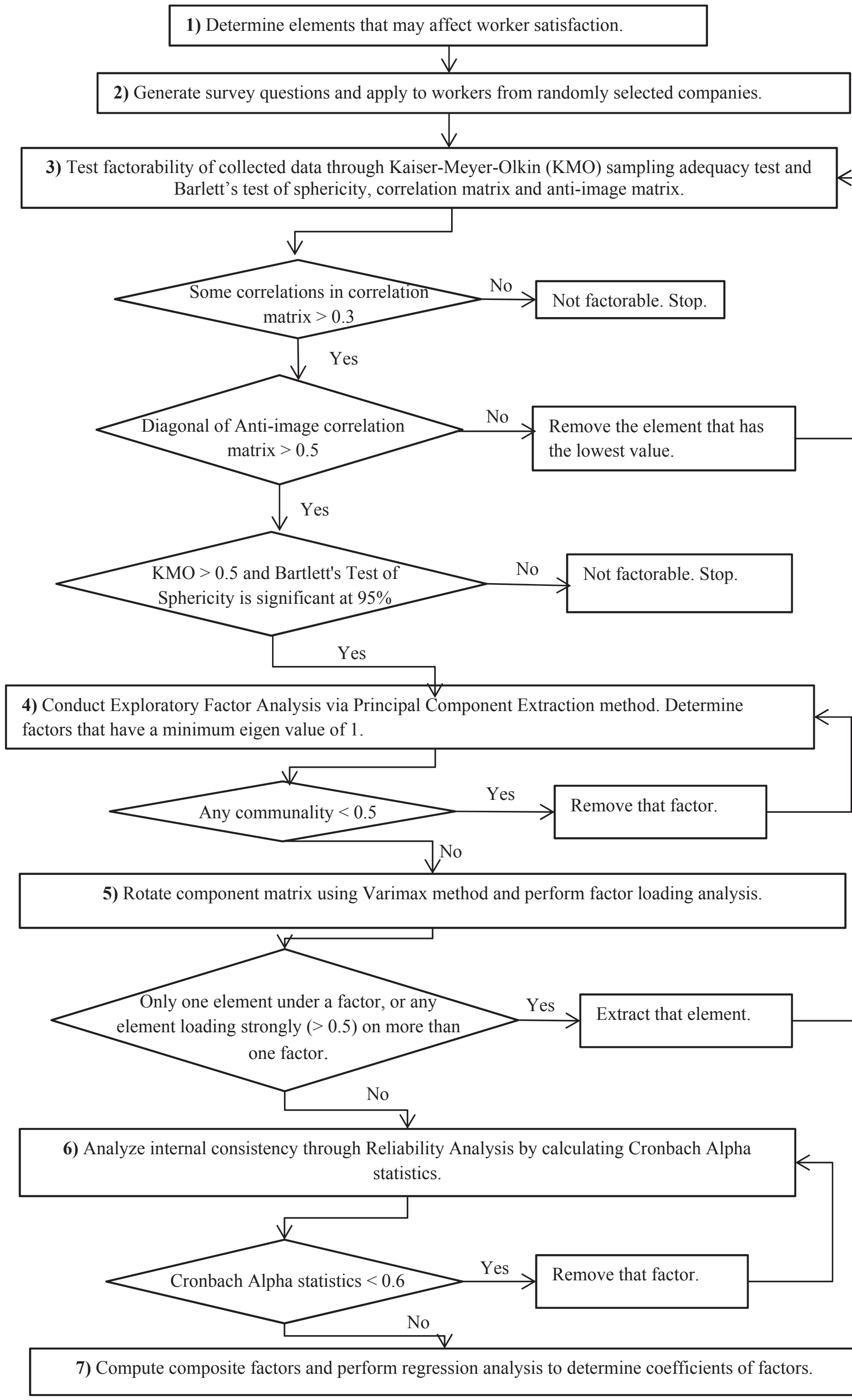

Fig. 2. Implemented research methodology to investigate principal factors of job satisfaction.

quality, safety, and human resource policies. The resulting factors and their elements are presented in Table 7. Interestingly, the principal factor of facility and equipment in the proposed conceptual model in Fig. 1 appears to be irrelevant for these workers. This might be related to the standards enforced by automotive manufacturers on their suppliers. Additionally, workers gave high importance to the factor of environmental conditions of the working area in the proposed model, and their inputs decomposed this factor into thermal comfort, air quality and disturbing equipment. Safety and ergonomics were very important distinct factors in the resulting model in contrast to the proposed model. Finally, human resource policies was included in the model as expected.

We performed a reliability analysis for each factor to assess its internal consistency using Croanbach's α correlation coefficient.

Table 3
Descriptive statistics.

Gender	%	Age	%	Marital status	%	Education	%	Working experience	%
Male	94.3	18–25	15	Single	41.4	High school	22	<1 year	15
Female	5.7	25–35	49	Married	58.6	Vocational school	65	1–3 years	17
		35–45	29			Bachelor's degree	13	3–5 years	8.2
		>45	7					6–10 years	35.8
								11–15 years	15
								>15 years	9

Table 4
Removed elements due to low individual KMO values in the anti-correlation matrix.

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Element	E27	E32	E18	E7	E17	E19	E15	E13
Individual KMO	0.283	0.311	0.344	0.356	0.397	0.335	0.420	0.443

Table 5
KMO and Bartlett's test results.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.607
Bartlett's Test of Sphericity	Approx. Chi-Square	649.095
	Df	300
	Sig.	0.000

Table 6
Eigenvalues of the final components and the amount of variance explained by them. Bold and underlined components represent the principal underlying components with their eigenvalues.

Component no.	Initial eigenvalues			Component no.	Initial eigenvalues		
	Total	% of Variance	Cumulative %		Total	% of Variance	Cumulative %
1	**3.709**	**20.604**	**20.604**	10	0.588	3.266	87.172
2	**3.158**	**17.544**	**38.148**	11	0.507	2.818	89.991
3	**2.027**	**11.261**	**49.409**	12	0.44	2.447	92.437
4	**1.537**	**8.538**	**57.947**	13	0.339	1.882	94.319
5	**1.225**	**6.806**	**64.753**	14	0.284	1.579	95.898
6	**1.126**	**6.257**	**71.010**	15	0.256	1.421	97.318
7	0.854	4.745	75.755	16	0.184	1.023	98.341
8	0.759	4.216	79.971	17	0.157	0.874	99.215
9	0.708	3.935	83.906	18	0.141	0.785	100

Table 7
Resulting factors and distribution of elements.

Factor No	Factor name	Related elements
F1	Ergonomics	(E3) Frequency of lifting heavy loads (E6) Painful positions (E12) Support of good posture (E14) Repetitive movements (E33) Standing and squatting
F2	Disturbing equipment	(E8) Noise of the working area (E10) Vibration of the working area
F3	Thermal comfort	(E20) Humidity of the working area (E30) Temperature of the working area
F4	Air qualify	(E29) Smell of the working area (E21) Dust of the working area (E22) Ventilation of the working area
F5	Safety	(E23) Safety of the working area (E31) Laceration risk
F6	Human Resource Policies	(E4) Job security (E5) Flexibility of working hours (E9) Salary (E26) Promotion

Even though alpha values are preferred to be between 0.7 and 0.9, they are still accepted if more than 0.6 (Nunnally and Bernstein, 1994). According to the results of this analysis given in Table 8, factors 1 through 5 are reliable because their alpha values were greater than 0.6. However, the alpha value of F6 fell slightly below 0.6. Although this indicates that this factor has a weak internal reliability, we decided not to remove it from our model, principally because its internal consistency value was very close to the acceptable limit and because previous research, as discussed earlier, has shown that human resource policies are an important factor for job satisfaction. We therefore conducted a regression analysis without removing F6.

Table 8
Results for the internal consistency values of factors.

	F1	F2	F3	F4	F5	F6
Cronbach α	0.624	0.663	0.776	0.619	0.684	**0.593**

Using IBM SPSS Statistics 20 for Windows, we performed a

Table 9
Results of the regression analysis with 6 factors.

Independent Variable	Unstandardized coefficients B	Unstandardized coefficients std. Error	Standardized coefficients (Beta)	t-value	P (significance)
F1	1.711	0.452	0.721	8.335	0.000
F2	1.234	0.131	0.584	7.949	0.000
F3	0.986	0.109	0.341	3.697	0.000
F4	0.879	0.027	0.041	−1.991	0.000
F5	0.634	0.213	0.678	1.824	0.000
F6	0.593	0.101	0.359	−1.356	0.000
Constant (B_0)	2.019				
Model Fit:	R^2: 0.772	P < 0.001			

regression analysis with job satisfaction as the dependent variable and the factors as independent variables using the method of least squares to fit the data to a linear model. The results are given in Table 9. This model produced the following formula for determining the job satisfaction score for worker *i* ($\mathbf{y_i}$) from the six factors in Table 7:

$$y_i = 2.019 + 1.711\ F1_i + 1.234\ F2_i + 0.986\ F3_i + 0.879\ F4_i + 0.634\ F5_i + 0.593\ F6_i, \quad (1)$$

where $\mathbf{F1_i}$, $\mathbf{F2_i}$, $\mathbf{F3_i}$, $\mathbf{F4_i}$, $\mathbf{F5_i}$, and $\mathbf{F6_i}$ are the factor satisfaction scores for worker *i*, respectively.

The equation indicates that the most important factor for job satisfaction in these workers is ergonomics whereas human resource policies have almost three times less effect on job satisfaction. When we investigated possible reasons for this, we were told that companies in the Turkish automotive industry pay higher salaries and provide better benefits than other industries, despite lagging behind European standards. We were also told that safety standards have slightly improved in the last 5 years due to new governmental regulations, although many ergonomic issues are still ignored. Eurofound (2012) also revealed a similar situation for companies in Turkey (see Section 1 for further discussion).

3.1. Practical considerations of usage of the model

In order to show how to use the job satisfaction formula given in Equation (1) in practice, this section provides an illustrative case. Remember that we constructed the survey using a five-point Likert scale to collect data for investigating the importance of the proposed principal job satisfaction factors not the level of satisfaction. However, to be able to use Equation (1) for evaluating an individual worker's satisfaction, we need to know how satisfied he/she is by the existing condition of the job satisfaction element, which requires a new survey to measure levels of satisfaction for each job satisfaction element.

Constructing such a survey creates a slight difficulty because some job satisfaction elements had negative weights on their principal factors, while others had positive (see in Table A4 in the Appendix). For example, lower values of E14 (repetitive motions) mean higher values of F1 (negative) whereas higher salary of E9 means higher values of F6 (positive). In order to overcome this difficulty and for ease of use of the model in future, we define a new five-point Likert scale to collect data for evaluating workers' actual satisfaction scores. In this scale, level 1 represents "strongly disagree" whereas level 5 means "strongly agree" with a statement, such as "I am satisfied by the existing condition or level of an element in my company." Hence, higher the rating is for each element within a factor, the higher the score for the factor overall. Thus, we can use the absolute values of the factor loadings of the elements in the final rotated matrix as weights to define a weighted satisfaction score on each factor for person *i* as given in Equation (2) through (7). This method, known as a weighted average, is rarely used because it is overly simplistic; however it is the easiest way to explain the principle (Field, 2013).

$$F1_i = 0.847\ E3_i + 0.732\ E6_i i + 0.697\ E14_i + 0.638\ E12_i + 0.59\ E33_i \quad (2)$$

$$F2_i = 0.897\ E8_i + 0.767\ E10_i \quad (3)$$

$$F3_i = 0.937\ E20_i + 0.876\ E30_i \quad (4)$$

$$F4_i = 0.713\ E29_i + 0.709\ E21_i + 0.544\ E22_i \quad (5)$$

$$F5_i = 0.715\ E31_i + 0.565\ E23_i \quad (6)$$

$$F6_i = 0.820\ E5_i + 0.804\ E4_i + 0.519\ E9_i + 0.648\ E26_i \quad (7)$$

For example, in Equation (2), $F1_1$ represents the satisfaction score of factor 1 (ergonomics) for worker 1. Likewise, $E3_1$ is the Likert value between 1 and 5 that worker 1 presents to the statement related with element number 3 (frequency of lifting heavy loads). Finally, in order to calculate the final satisfaction score of worker *i* (y_i) using Equation (1), the scores for each factor should be calculated separately before entry into Equation (1).

Now let us give an example case to derive both factor scores and a final satisfaction score. Assume that new survey data was collected showing the workers' levels of satisfaction. If a worker responds that he/she strongly agrees with the existing condition or level of every element in each factor then every element takes a value of 5, so factors F1 through F6 score 17.52, 8.32, 9.07, 9.83, 6.4 and 13.96, respectively. If these values are entered into Equation (1), they yield a final satisfaction score of 72.17, which is the maximum level of satisfaction possible. In contrast, the final satisfaction score of a worker who strongly disagreed with every statement, scoring 1 on each, would be 16, which is the minimum possible in Equation (1).

It should be noted that the maximum score is less than 100, which seems to underestimate the actual satisfaction score. The main reason of this is that the factors and their elements explain 71% of the total variance because several elements were either removed during the factor analysis or not included in the model due to weak loadings.

Thus, using these equations, managers can calculate both the overall satisfaction scores of their workers and the component scores in terms of the 6 principal factors. Managers can then use these scores to identify problematic factors or elements that need to be addressed to improve worker satisfaction.

4. Conclusion

Even though there has been intensive research on job satisfaction, to the best of our knowledge, no study has looked holistically at the job satisfaction of manufacturing workers by considering its different aspects. Focusing on the manufacturing environment, we proposed a new and extensive model of job satisfaction comprising four principal factors: environmental conditions of the working area, ergonomics and safety, human resource policy and management, and facility and equipment. We identified 34 job satisfaction elements under these principal factors. Our proposed model is the first model that considers an extensive list of elements in a structured way.

In order to test the proposed model, we conducted a survey in the automotive industry in Turkey to examine the perceived importance of different job elements. We then performed an exploratory factor analysis to determine relationships among job satisfaction elements and potential factors to see if the proposed model was valid or not. The factor analysis revealed six underlying factors with 18 job satisfaction elements. Interestingly, no job satisfaction elements under the principal factor of facility and equipment in the proposed conceptual model appeared relevant to the workers who participated in the survey. This may be related to the standards enforced by international automotive manufacturers on their suppliers in Turkey. In contrast, workers think that the environmental conditions of the working area, and safety and ergonomics play a very important role in determining job satisfaction. However, the factor analysis separated these proposed factors. In the resulting model, most of the job satisfaction elements under these factors were divided among five new principal factors, which we labeled thermal comfort, air quality, disturbing equipment, ergonomics and safety. Additionally, as expected, human resource policies was retained in the resulting model.

We then developed a formula for evaluating workers' actual satisfaction scores based on the resulting model using multilinear regression analysis. We also develop formulas for the satisfaction scores of each principal factor in the model by considering the weight of their underlying elements. We believe this is the first attempt to present such a model and equations for job satisfaction in a specific industry. Interestingly, the equation shows that the most important factor determining job satisfaction is ergonomics, which is three times more important than human resource policies, which has the least effect on job satisfaction. According to our experience, this is an interesting result because modern human resource policies have only slowly been implemented in Turkish manufacturing industry due to a large labor pool and low labor wages. However, Turkey's developing automotive industry has attracted many new international automotive manufacturers and their main suppliers to open or move their facilities there because of its closeness to both European and emerging Middle Eastern markets, advantages of lower wages than European countries, and accumulated knowledge in automotive production. Therefore, demand in Turkey's automotive labor market has been increasing so companies in this industry have improved wage levels and implemented modern human resource policies, such as flexible hours or promotion systems, to retain workers by increasing their job satisfaction. However, the model also indicates that ergonomics and environmental factors are still problems in these companies even though safety standards have slightly improved due to newly implemented regulations. Thus, as Eurofound (2012) also revealed, companies in the automotive industry should focus on improving ergonomics and environmental factors in their manufacturing environment if they want to increase their workers' job satisfaction.

Conflict of interest

The authors declare that they have no conflict of interest.

APPENDIX

Table A1
Communality values of 26 elements remained after factorability test.

Element No	Initial	Extraction	Element no	Initial	Extraction
E1	1.000	0.721	E20	1.000	0.674
E2	1.000	0.612	E21	1.000	0.828
E3	1.000	0.683	E22	1.000	0.635
E4	1.000	0.663	E23	1.000	0.714
E5	1.000	0.569	E24	1.000	0.681
E6	1.000	0.560	E25	1.000	0.739
E8	1.000	0.818	E26	1.000	0.658
E9	1.000	0.829	E28	1.000	0.821
E10	1.000	0.730	E29	1.000	0.864
E11	1.000	0.829	E30	1.000	0.813
E12	1.000	0.680	E31	1.000	0.820
E14	1.000	0.609	E33	1.000	0.759
E16	1.000	0.644	E34	1.000	0.684

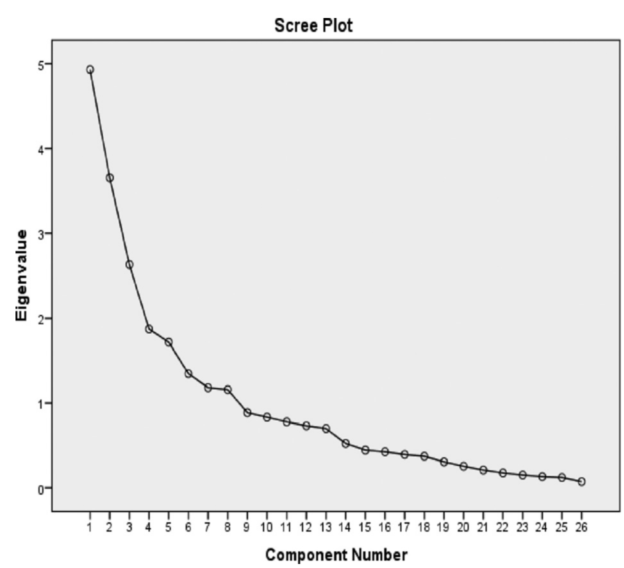

Fig. A1. Scree plot of initial eigenvalues of 26 elements after factorability test.

Table A2
Initial eigenvalues of remaining 26 elements after factorability test and the amount of explained variance.

Element No	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
E1	4.931	18.966	18.966	4.931	18.966	18.966
E2	3.656	14.061	33.028	3.656	14.061	33.028
E3	2.632	10.123	43.150	2.632	10.123	43.150

Table A2 (*continued*)

Element No	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
E4	1.872	7.202	50.352	1.872	7.202	50.352
E5	1.717	6.604	56.956	1.717	6.604	56.956
E6	1.346	5.177	62.132	1.346	5.177	62.132
E7	1.181	4.542	66.675	1.181	4.542	66.675
E8	1.158	4.455	**71.129**	1.158	4.455	**71.129**
E9	0.885	3.405	74.535			
E10	0.832	3.201	77.735			
E11	0.777	2.990	80.725			
E12	0.731	2.811	83.537			
E13	0.699	2.688	86.225			
E14	0.523	2.011	88.236			
E15	0.445	1.710	89.946			
E16	0.425	1.633	91.578			
E17	0.393	1.510	93.088			
E18	0.372	1.429	94.517			
E19	0.306	1.175	95.693			
E20	0.255	0.980	96.673			
E21	0.210	0.807	97.480			
E22	0.176	0.677	98.157			
E23	0.152	0.583	98.740			
E24	0.132	0.509	99.249			
E25	0.122	0.470	99.719			
E26	0.073	0.281	100.000			

Table A3
Initial rotated component matrix obtained before reductions. Bold and underlined values represent the loaded elements onto the corresponding component.

Element No	Component							
	1	2	3	4	5	6	7	8
E8	**0.815**	0.075	−0.012	−0.102	−0.336	−0.024	−0.034	0.049
E9	**0.853**	0.085	−0.046	0.077	−0.063	−0.210	0.145	0.008
E11	**0.742**	0.352	−0.229	0.007	−0.100	0.252	0.110	0.134
E1	0.046	−**0.520**	0.236	0.237	0.102	0.369	−0.326	−0.275
E31	0.260	**0.832**	0.124	0.146	0.152	−0.010	0.058	−0.043
E33	0.226	**0.704**	0.317	−0.161	0.172	0.068	0.198	−0.109
E34	−0.049	**0.539**	0.247	−0.305	−0.101	0.297	0.329	0.083
E2	−0.067	−**0.454**	0.017	0.406	−0.177	0.168	0.103	−0.407
E29	−0.165	0.079	**0.895**	0.124	−0.031	0.052	0.042	−0.087
E30	0.044	0.078	**0.865**	−0.032	0.076	−0.194	0.041	−0.073
E16	−0.034	−0.474	0.188	**0.534**	−0.148	0.246	0.128	−0.022
E20	0.012	0.122	−0.100	−**0.547**	0.182	−0.405	0.350	0.071
E26	0.197	0.230	0.449	−**0.511**	−0.091	0.228	−0.026	0.207
E3	0.019	0.030	0.026	**0.776**	−0.193	−0.030	−0.102	0.100
E21	−0.252	0.031	−0.041	−0.040	**0.860**	0.077	0.007	0.086
E22	−0.118	0.280	−0.077	−0.207	**0.563**	−0.098	0.218	−0.343
E23	−0.010	0.111	0.194	−0.339	**0.684**	−0.295	0.041	−0.112
E6	−0.304	−0.023	−0.054	0.345	0.011	**0.555**	−0.090	0.169
E12	0.313	0.015	0.126	−0.150	0.192	**0.558**	0.106	0.019
E14	−0.006	−0.008	0.126	−0.002	0.141	−**0.747**	−0.071	−0.034
E4	−0.105	−0.181	−0.093	0.222	−0.304	0.005	−**0.646**	0.195
E5	−0.095	−0.251	0.090	0.113	0.020	0.093	−**0.603**	0.349
E10	0.379	−0.282	0.080	0.084	−0.204	0.176	**0.615**	0.216
E28	−0.186	0.262	0.334	0.298	0.322	0.179	**0.564**	0.273
E24	−0.038	0.015	0.274	−0.088	0.152	−0.154	0.069	−**0.720**
E25	0.531	0.091	0.196	−0.150	0.056	−0.047	−0.024	**0.614**

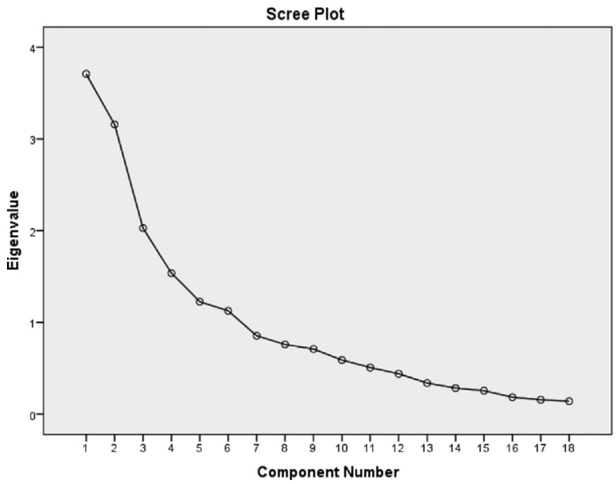

Fig. A2. Scree plot of eigenvalues of 18 elements after reductions.

Table A4
Final rotated component matrix used to obtain the final model after reductions. Bold and underlined values represent stongly loaded elements onto the corresponding component.

Element No	Component					
	1	2	3	4	5	6
E3	**0.847**	0.197	−0.090	−0.033	0.092	0.137
E6	**0.732**	0.310	−0.129	0.208	0.232	0.013
E14	−**0.697**	0.213	−0.108	0.098	0.019	0.161
E12	**0.638**	0.390	−0.286	0.165	−0.217	0.038
E33	−**0.590**	0.367	−0.103	0.371	0.183	0.235
E8	0.077	**0.897**	0.094	0.111	0.017	−0.057
E10	0.047	**0.767**	0.269	0.205	0.062	0.243
E20	−0.109	0.087	**0.937**	0.001	−0.069	−0.067
E30	−0.003	0.123	**0.876**	0.064	0.197	0.069
E29	0.114	−0.249	−0.112	−**0.713**	−0.010	−0.274
E21	−0.045	−0.151	0.034	−**0.709**	−0.136	0.018
E22	0.394	−0.213	0.106	**0.544**	−0.322	−0.014
E31	−0.232	0.012	−0.039	−0.267	−**0.715**	−0.125
E23	−0.417	0.276	0.074	0.175	**0.565**	0.396
E5	0.101	0.039	0.087	−0.131	−0.106	−**0.820**
E4	−0.060	0.002	0.076	−0.107	−0.066	**0.804**
E9	−0.084	0.061	−0.121	0.374	0.372	**0.519**
E26	0.256	0.251	0.352	−0.136	−0.159	**0.648**

References

Abdullah, M.A., Khalid, H.N., Shuib, M., Md Nor, N., Muhammad, Z., Jauhar, J., 2007. Job satisfaction amongst employees in small and medium industries (SMIs) in the manufacturing sector: a Malaysian case. J. Asia Pacific Bus. 8 (4), 39–66.
Ardakani, M.B., Zare, M., Mahdavi, S., Ghezavati, M., Fallah, H., Halvani, G., Bagheraat, 2013. A relation between job stress dimensions and job satisfaction in workers of a refinery control room. J. Community Health Res. 1 (3), 198–208.
Ayoub, M.A., 1990a. Ergonomic deficiencies: I. Pain at work. J. Occup. Environ. Med. 32 (1), 52–57.
Ayoub, M.A., 1990b. Ergonomic deficiencies: II. Probable causes. J. Occup. Environ. Med. 32 (2), 131–136.
Bartlett, M.S., 1950. Tests of significance in factor analysis. Br. J. Psychol. 3, 77–85.
Bauer, T.K., 2004. High Performance Workplace Practices and Job Satisfaction: Evidence from Europe (No. 1265) (IZA Discussion Paper Series).
Bilgiç, R., 1998. The relationship between job satisfaction and personal characteristics of Turkish workers. J. Psychol. 132 (5), 549–557.
Carlopio, J.R., Gardner, D., 1992. Direct and interactive effects of the physical work environment on attitudes. Environ. Behav. 24 (5), 579–601.
Cranny, C.J., Smith, P.C., Stone, E.F., 1992. Job Satisfaction: How People Feel about Their Jobs and How it Affects Their Performance. Lexington Books.
Dawal, S.Z., Taha, Z., 2006. Factors affecting job satisfaction in two automotive industries in Malaysia. J. Teknol. A 44 (A), 65–80.
Egan, T.M., Yang, B., Bartlett, K.R., 2004. The effects of organizational learning culture and job satisfaction on motivation to transfer learning and turnover intention. Hum. Resour. Dev. Q. 15 (3), 279–301.
Eurofound, 2012. Fifth European Working Conditions Survey. Publications Office of the European Union, Luxembourg, p. 45.
Fairbrother, K., Warn, J., 2003. Workplace dimensions, stress and job satisfaction. J. Manag. Psychol. 18 (1), 8–21.
Field, A., 2013. Discovering Statistics Using IBM SPSS Statistics. Sage.
Gerhart, B., 1987. How important are dispositional factors as determinants of job satisfaction? implications for job design and other personnel programs. J. Appl. Psychol. 72 (3), 366.
Griffeth, R.W., Hom, P.W., Gaertner, S., 2000. A meta-analysis of antecedents and correlates of employee turnover: update, moderator tests, and research implications for the next millennium. J. Manag. 26 (3), 463–488.
Griffin, M.A., Patterson, M.G., West, M.A., 2001. Job satisfaction and teamwork: the role of supervisor support. J. Organ. Behav. 22 (5), 537–550.
Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., Tatham, R.L., 2006. Multivariate Data Analysis, sixth ed. Pearson Prentice Hall, Upper Saddle River, NJ.
Kahya, E., 2007. The effects of job characteristics and working conditions on job performance. Int. J. Ind. Ergon. 37 (6), 515–523.
Kaiser, H.F., 1970. A second generation little jiffy. Psychometrika 35 (4), 401–415.
Kaiser, H.F., 1974. An index of factorial simplicity. Psychometrika 39, 31–36.
Kittusamy, N.K., Buchholz, B., 2004. Whole-body vibration and postural stress among operators of construction equipment: a literature review. J. Saf. Res. 35 (3), 255–261.
Kline, P., 2014. An Easy Guide to Factor Analysis. online ed., Routledge, USA.
Lee, Y.S., Guerin, D.A., 2009. Indoor environmental quality related to occupant satisfaction and performance in LEED-certified buildings. Indoor Built Environ. 18 (4), 293–300.
Lund, T., Labriola, M., Christensen, K.B., Bültmann, U., Villadsen, E., 2006. Physical work environment risk factors for long term sickness absence: prospective findings among a cohort of 5357 employees in Denmark. Br. Med. J. 332 (7539), 449–452.
MacIntosh, E.W., Doherty, A., 2010. The influence of organizational culture on job satisfaction and intention to leave. Sport Manag. Rev. 13 (2), 106–117.
Marshall, A.W., Olkin, I., 1974. Majorization in multivariate distributions. Ann. Stat. 1189–1200.
Martel, J.P., Dupuis, G., 2006. Quality of work life: theoretical and methodological problems, and presentation of a new model and measuring instrument. Soc. Indic. Res. 77 (2), 333–368.
Marras, W.S., Allread, W.G., Burr, D.L., Fathallah, F.A., 2000. Prospective validation of a low-back disorder risk model and assessment of ergonomic interventions associated with manual materials handling tasks. Ergonomics 43 (11), 1866–1886.
Mobley, W.H., Griffeth, R.W., Hand, H.H., Meglino, B.M., 1979. Review and conceptual analysis of the employee turnover process. Psychol. Bull. 86 (3), 493.
Newsham, G., Brand, J., Donnelly, C., Veitch, J., Aries, M., Charles, K., 2009. Linking indoor environment conditions to job satisfaction: a field study. Build. Res. Inf. 37 (2), 129–147.
Nunnally, J.C., Bernstein, I.H., 1994. Psychometric Theory, third ed. McGraw-Hill Inc, USA.
Randolph, D.S., 2004. Predicting the effect of extrinsic and intrinsic job satisfaction factors on recruitment and retention of rehabilitation professionals. J. Healthc. Manag. Am. Coll. Healthc. Exec. 50 (1), 49–60.
Røssberg, J.I., Eiring, Ø., Friis, S., 2004. Work environment and job satisfaction. Soc. Psychiatry Psychiatric Epidemiol. 39 (7), 576–580.
Schawbel, D., 2011. Who's at Fault for High Gen-y Turnover? Forbes (accessed 15.10.14.). http://www.forbes.com/sites/danschawbel/2011/11/22/whos-at-fault-for-high-gen-y-turnover/.
Shikdar, A.A., Sawaqued, N.M., 2003. Worker productivity, and occupational health and safety issues in selected industries. Comput. Ind. Eng. 45 (4), 563–572.
Smith, P.C., Kendall, L.M., Hulin, C.L., 1969. The Measurement of Satisfaction in Work and Retirement. Rand McNally, Chicago, IL.
Sims, H.P., Szilagyi, A.D., Keller, R.T., 1976. The measurement of job characteristics. Acad. Manag. J. 19 (2), 195–212.
Synwoldt, U., Gellerstedt, S., 2003. Ergonomic initiatives for machine operators by the Swedish logging industry. Appl. Ergon. 34 (2), 149–156.
Tabachnick, B.G., Fidell, L.S., 2012. Using Multivariate Statistics, sixth ed. Pearson Education Inc, Boston.
Turcotte, P.R., 1988. La qualité de vie au travail: une voie vers l'excellence. Montréal: Agence d'Arc.
Wright, B.E., Davis, B.S., 2003. Job satisfaction in the public sector the role of the work environment. Am. Rev. Public Adm. 33 (1), 70–90.