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ORIGINAL RESEARCH

# Promoting work Engagement in the Accounting Profession: a Machine Learning Approach

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**Abstract**
In this paper, a non-linear multi-dimensional (machine learning-based) index for accountants that relates work engagement scores (according to accountants' perceptions) with the seven Job Quality Indices (JQI) (proposed by Eurofound) has been proposed. The goal of the research is two-fold, namely, (i) to quantify the extent to which the JQI variables explain the work engagement scores, and (ii) to determine which JQI variables most affect the work engagement scores. The best performing regression model achieved a competitive root mean square percentage, highlighting that the selected variables primarily determine the work engagement values. Other important findings include (i) that the work engagement index is mainly influenced by the social environment index and (ii) that the skills and discretion and prospects indices are also crucial in the promotion of the work engagement of accountants. The instrument implemented could be employed by human resources practitioners to propose efficient human resources strategies that improve both individual well-being and company performance in the accounting sector.

**Keywords** Accountants · Global sensitivity analysis · Multi-dimensional indices · Work engagement · Job quality

## 1 Introduction

Audit firms are increasing their interest in employee well-being because it positively affects the effectiveness of the work and could consequently improve both individual well-being and company performance. In fact, job conditions in the audit firms critically influence processes such as knowledge acquisition in the sector or professional skepticism with which the accountants approach tasks or decisions (Robinson et al., 2018). For instance, PwC asserts as follows: "*Be well, work well - Given the pace and complexity of change,*

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*the firm is putting the power of its resources towards supporting our people's journey to greater well-being. In FY19, the firm continued to support our people's well-being journey; including the use of a digitally-enabled employee Well Being Rewards program. This is complemented with periodic firmwide events (e.g., PwC on the Move, 50k Random Acts of kindness, The Big Breathe, Day of Joy/Purpose), which focus on enhancing personal well-being*"[1].

Audit work is carried out under significant pressure that peaks in the seasons associated with information preparation and auditing. Thus, accountants experience a significant concentration of work around the date of the accounting close and the subsequent months that are known as peak. In addition, the audit activity is subject to commercial pressure because the auditors act on a competition basis: this leads them to adjust their prices. Prior literature (Pierce & Sweeney, 2004; Gundry & Liyanarachchi, 2007) and international standards for quality work warn that tight time schedules can threaten the quality of audit work (IAASB 2014). The International Federation of Accountants (IFAC) Code of Ethics, issued by the International Ethics Standards Board for Accountants (IESBA), also illustrates the effects on the principles of competence and due care arising from the lack of time to perform the relevant tasks, lack of information, and inadequate training (IESBA, 2012). Finally, although a certain degree of staff turnover is unavoidable in the sector, the excessive levels of turnover that characterize this activity definitely affect the quality of the audit work, as reported by the PCAOB (2015).

Recently, the Public Company Accounting Oversight Board (PCAOB) has launched a consultation regarding improvements in the quality systems of audit work. In the consultation, Robert Conway (a certified public accountant in the United States) claimed that the mismanagement of human capital by large audit firms is a serious threat to audit quality (Conway, 2020). The stress in the audit teams is increased by several factors such as the high turnover, the emergence of new orders for corporate operations of customers, the increase of working hours planned and adjusted planning of hours to be competitive. The consequences of high workload and staff turnover are increases in threats to the quality of the audit (PCAOB, 2015). In addition, Persellin et al. (2019) point out that high workload negatively affects job satisfaction: especially when the former exceeds the level that is considered to affect audit quality. Finally, auditor intrinsic motivation is positively related with the quality of audit judgements (Kadous & Zhou, 2019). Intrinsic motivation is the engagement in an activity for its own sake (Loscalzo & Giannini, 2019). Hence, this paper examines human resources literature for proposing how job quality management could improve work engagement in audit work.

Work engagement is a concept composed of three constructs: vigor, dedication and absorption (Schaufeli et al., 2002). Prior research on human resources management has shown that work engagement and the level of performance of employees are positively correlated (Markos & Sridevi, 2010; Leroy et al., 2013). In this context, Du Plooy and Roodt (2010) pointed out that there exists a negative correlation between work engagement and staff turnover. Therefore, it could be claimed that working conditions influence workers' mental health and quality of work. However, unlike other professions, auditing has a social function which is preserved through institutional mechanisms for ensuring the quality of audit reports. In addition to ensuring the independence of the professional and the technical

[1] PwC. Our 2019 Audit Quality Report. 2019. Available at: https://www.pwc.com/us/en/services/audit-assurance/assets/pwc-2019-audit-quality-report.pdf.

skills that assure quality, it is necessary to design mechanisms to improve the mood of professionals in the development of their work.

Extensive research has analysed the relationship between working conditions and work engagement; however, as far as our knowledge extends, very few research endeavors have focused their attention on audit work, let alone taking a holistic approach as allowed by the indicator system proposed by the EU. Motivated by all of these points, the aim of this paper is two-fold: (i) measuring the relationship among work engagement and job quality in the accountancy profession following the holistic approach proposed by the EU and (ii) identifying the job quality components that most impact the work engagement construct. As described previously, the promotion of work engagement is a key factor for accountant professionals. Thus, the model implemented will help human resources practitioners to propose efficient human resources strategies in the accounting professional sector that optimize both individual well-being and company performance.

Methodologically speaking, this paper analyses the accuracies through a set of non-linear regression models (machine learning based) in the work engagement estimation problem to assess the extent to which job quality variables explain the variations of the work engagement scores. The selected models are superior to the classical statistical methods in modelling the non-linear interactions between input variables. Furthermore, an original procedure to determine the relative importance of the job quality variables in the work engagement estimation problem has also been proposed. Hence, one of the main objectives of the manuscript is to show how to construct a multi-dimensional index through the combination of machine learning-based models and sensitivity analysis to social scientists and practitioners

The structure of the rest of the paper is as follows. The next section briefly reviews the concepts of work engagement and job quality in the accountancy profession. Section 3 describes the main variables and data that are considered as key to the estimation of the work engagement construct in the accountancy profession. A brief description of the methodological approach adopted is detailed in Sect. 4. The experimental study of the paper, along with the results obtained, are reported in Sect. 5, whereas the discussion of those results is included in Sect. 6. Finally, the paper is concluded with some remarks and conclusions in Sect. 7.

## 2 Work Engagement and Job Quality in the Accountancy Profession

Work is a fundamental element of the integral development of any person because it constitutes the main path of access to income produced and is generally configured as a nuclear element of life in terms of time, social integration and individual self-esteem (Anker et al., 2003). From this perspective, and as Clark (2015) points out, work is one of the most critical factors for the development of the well-being of many individuals.

Despite this manifest importance, the debate on employment and its quality is far from closed in academic literature; among other reasons, this is because there is no universal consensus on how job quality should be understood. Therefore, Muñoz de Bustillo et al. (2011) warn of different proposals that sometimes contradict each other. Without a doubt, we are faced with a diffuse concept which has multiple edges and different dimensions (Clark 2015). Given the interaction between the various aspects, it is essential, as recommended by Charlesworth et al. (2014), to research job quality from a comprehensive point of view. Green et al., (2006) asserts that job quality would be made up of all those

conditions of work that the employees value and that determine their well-being. This component of personal perception causes a new conception factor, since the importance given to different dimensions can vary between subjects and may even evolve within the same individual over time.

The complexity of specifying what to understand by job quality explains the difficulty in measuring this concept. Currently, there are two main approaches. On the one hand, the European Union's strategy is geared towards creating more and "better jobs". On the other hand, the International Labour Organization (ILO) approach introduces the concept of decent work consistent with the eighth Sustainable Development Goal (decent jobs and economic growth) proposed by the United Nations. While the approach developed by the ILO considers the personal circumstances of employees and their employment context, such as the unemployment rate, the European Union proposal seeks to obtain an indicator of job quality that is independent of personal circumstances and situations in the labour market. It, therefore, seeks to identify objective conditions of work that meet the needs of employees.

In this paper, the European Union proposal is chosen as indicated by Grimshaw et al. (2017); Europe is the place for which the most information is available and reliable. The European Union's proposal is based on a battery of indicators that aims to measure the quality of employment in different jobs and sectors of activity through harmonized surveys. Green and Mostafa (2012) develop this methodology, leading to seven indicators of the quality of employment. The main strength of this approach is the ability to monitor and compare the quality of employment holistically between the different countries that constitute the EU over time. In addition, it assesses the effects of working conditions on different outcome variables such as health problems, subjective well-being, work-life meaningful balance, meaningfulness of work, or, in relation to the main purpose of this research, Work Engagement.

### 2.1 Work Engagement

One of the phenomena with which job quality has a closer relationship is undoubtedly the attitude that the employee develops towards his work. Precisely, this research adopts as a reference point the new trends about positive psychology, thus considering that work engagement constitutes a positive, fulfilling, work-related state of mind (Schaufeli and Bakker, 2004), along with a positive and persistent emotional affective state in employees, characterized by vigour, absorption and dedication Schaufeli et al. 2002.

Extensive research has studied the relationship between job quality and work engagement. Thus, work engagement has been investigated in different sectors of activity: in the third sector (Selander 2015), among dependent self-employees (Navajas-Romero et al., 2019), in the manufacturing industry (Luu et al., 2019), or in the service sector (Connell et al., 2014), among others. Other researchers have focused on different jobs: hotel employees (Lee et al., 2015), physicians (Ferraro et al., 2020), call centre workers (Mustosmäki et al., 2013), or teachers (Hakanen et al., 2006). For example, the recent work by Ferraro et al. (2020) analyzes the antecedents of work engagement and burnout using the Utrecht work engagement scale and a sample of 605 Portuguese and Brazilian physicians, concluding that job demands and job resources are the main predictors of burnout and work engagement, respectively. On the other hand, the research by Lee et al. (2015) studies the drivers of work engagement in a completely different work context (394 hotel line-employees and managers in the United States). The results obtained after applying multiple

regression models confirm that core self-evaluation and certain dimensions of psychological climate (e.g. managerial support for service or information-sharing communication) are positively related to the level of work engagement developed by employees. For those readers who wish to delve into this matter, the systematic review by Bailey et al. (2017) out of a total of 214 studies shows the meaning, antecedents and primary outcomes of work engagement, as well as the role that working conditions play in the development of this link. These authors claimed that the dimensions that act as antecedents of work engagement are: individual psychological states (e.g. self efficacy, resilience, positive affect or psychological empowerment); job-design-related factors (autonomy, feedback, working hours or teleworking, among others); perceived leadership and management (e.g. leadership styles, trust in manager/leader); organizational and team factors (e.g. climate and communication between team members); and organizational interventions (e.g. mindfulness training). Likewise, the primary outcomes identified can be grouped into two categories: performance and moral. On the one hand, work engagement would be positively related to organizational and team performance, at the macro level, and to task performance, extra-role performance, and counterproductive performance, on a more micro or individual level. On the other hand, another group of studies have examined the moral outcomes of work engagement, focusing mainly on well-being (e.g. life satisfaction) and health perception (e.g. stress or burnout).

One of the main characteristics of previous research is the focus on specific and partial features of working conditions offered by companies: job crafting and job insecurity (Lu et al., 2014), compensation and remuneration policy (Taufek et al., 2016), stress and burnout (Rothmann, 2008), or workload (Zahrah et al., 2019). None of them performs a systematic and broad-spectrum study of the job quality in the auditing profession or, of course, its influence on the work engagement of professionals working in this sector.

Among professional accountants, the research on work engagement is very scarce. For example, Yakın and Erdil (2012) report that personal traits especially influence work engagement in the accountancy profession. They argue that the job characteristics of the sector require employees with particular traits. Hence, people focused on results could adequately address the highly stressful activity of auditing. They also demonstrate, empirically, the relationship between focused effort, a dimension of self-efficacy, and work engagement.

Work engagement is positively related to job satisfaction in different jobs (Saks, 2006; Yeh, 2013), including of course the accountancy profession (Yakın & Erdil, 2012). Nonetheless, an intense debate exists about whether work engagement is an antecedent or consequence of job satisfaction (Rayton & Yalabik, 2014). However, Rothmann (2008) asserts that well-being has unfortunately been narrowly operationalized as job satisfaction. He demonstrates that work-related well-being integrates three additional dimensions to job satisfaction: occupational stress, burnout and work engagement.

As will be exhibited in the next section, the auditing profession presents certain particularities that suggest the need for an ad hoc study of these aspects.

### 2.2 Job Quality in Auditing Context

The measurement of job quality is a controversial issue. There are two approaches to capture this concept. The first one measures the condition of job quality through a direct question to the individual. The second one tries to identify the features of job quality. This

latter approach yields a more consistent measurement between subjects because all of them assess the same array of attributes.

Parent-Thirion et al. (2016) proposed an index with seven dimensions for tackling the job quality concept. These dimensions are physical environment, work intensity, work time quality, social environment, skills use and job discretion, prospects and earnings. These variables apply to many different jobs. In the accountancy environment, the main threats are the job demands (work intensity), and the strengths come from job resources (work time quality, social environment, skills application and job autonomy, prospects in the career, and finally the compensation).

A moderate level of work intensity stimulates and leads to higher performance levels, but this relationship takes the form of an inverted U, and as the stressors overcome a certain level, the individual performance worsens. Job demands have been negatively associated with burnout (Fogarty et al., 2000; Sweeney & Summers, 2002). However, partners are at the highest hierarchical levels and are the ones who experience the most work overload, yet, interestingly, also declare greater job satisfaction (Sanders et al., 1995). This result does not apply to other categories within these organizations and can be explained by the influence of compliance with professional expectations, in the case of partners, or the impact of superior work engagement.

Tight deadlines and staff shortages explain the workload, and its effects can include a reduction of the scope in the audit procedures, a reduction in professional skepticism, and difficulty retaining experienced staff (Christensen et al., 2016). The approach used by firms is more targeted at workload management than its reduction[2] The accumulation of job resources could mitigate the negative effect of excessive job demands. These job resources can reside in the individual or can be developed by the organization. Among the former, the development of the capabilities themselves allows work under pressure to be stimulating; job crafting would, therefore, improve the negative influence of job demands on employee health and motivation. Among the resources developed by the organization are the design of a career, financial compensation or the formation of work teams that help to cope with stressors.

A significant number of accountants work in highly hierarchical structures: the audit firms (Collins and Killough 1989). Recognition by hierarchical superiors is important for the professional to maintain motivation (Pierce & Sweeney, 2004; Umans et al., 2016), and career progress concerns combined with job ambiguity impair job satisfaction (Kelly & Barrett, 2011). In addition, teamwork must be followed for fair treatment between individuals to maintain a proper workplace atmosphere (Herda & Lavelle, 2012; Cannon & Herda, 2016), and career prospects and personal growth are the basis for electing accountancy as a labour choice (Umar et al., 2017).

## 3 Data and Variables Involved in the Theoretical Model

The data used for the development of this research study were obtained from the sixth European Working Conditions Survey (EWCS), which was developed by the European Foundation for the Improvement of the Conditions of Life and Work in 2015 (Parent-Thirion et al.,

[2] KPMG. Our Investment in audit quality. 2015. Available online at: https://assets.kpmg/content/dam/kpmg/pdf/2016/04/our-investment-in-audit-quality.pdf.

2016). This survey analyses the working conditions in the 27 countries of the European Union, providing valuable information on different aspects of the working conditions in Europe.

To achieve the goals of the present study, a sub-sample of 739 professional accountants was extracted using codes 2411 (accountants) and 3313 (accounting associate professionals) of the International Standard Classification of Occupations. For the model implementation, the variables associated with the Job Quality Indices (JQI) are used as independent variables, where the work engagement index is the dependent one. Additionally, three socio-demographics were also considered in the study for sample characterization.

### 3.1 JQI-Related Variables

This section describes the seven indices of job quality developed by Eurofound in its report about the topic (Parent-Thirion et al., 2016). The implementation of the seven indices reflects the multi-dimensional nature of the concept of job quality and the fact that each dimension exerts an impact on the health and well-being of employees and their corresponding work engagement. Thus, the indices that operationalize the multi-dimensional construct of job quality are:

- *Physical environment (JQI 1)* The physical environment index (JQI 1) measures the physical risks employees encounter in their jobs. The index comprises 13 indicators related to specific physical hazards such as exposure to noise, dust, chemicals or infectious agents; lifting heavy loads; and repetitive hand movements. As described in the last EWCS report, the EU28's employees have slightly improved their scores in this particular index (Parent-Thirion et al., 2016). The index will be denoted as $X_1$ for the mathematical model.
- *Work intensity (JQI 2)* The work intensity index (JQI 2) measures the level of job demands for the European employees. If those demands are high, the job requires excessive mental and physical energy. Likewise, if the job involves juggling with the job demands, it becomes difficult for employees to perform well in their tasks. The index comprises 13 items related to quantitative demands (working rapidly), time pressure (having tight deadlines, not having enough time to do the job), frequent disruptive interruptions, pace determinants and interdependency, and emotional demands. Unfortunately, the work intensity index shows an increase in the job demands on the European employees in the last ten years. The index will be denoted as $X_2$ for the mathematical model.
- *Working time quality (JQI 3)* The working time quality index (JQI 3) is a multi-dimensional construct composed of four elements: duration, atypical working time, working time arrangements and flexibility. The index values show that working time quality has increased or remained stable in most European countries during recent years (Parent-Thirion et al., 2016). The index will be denoted as $X_3$ for the mathematical model.
- *Social environment (JQI 4)* The social environment index (JQI 4) measures the extent to which employees experience supportive social relationships either with their peers or supervisors. The index comprises 15 items organized around two concepts: the incidence of adverse social behaviour and the presence of support. Unfortunately, the comparison over time is not possible because some questions were reformulated in the 2015 version of the report (Parent-Thirion et al., 2016). The index will be denoted as $X_4$ for the mathematical model.

- *Skill use and discretion (JQI 5)* The skills and discretion index (JQI 5) measures the skills needed to perform well in the job under study. It also analyses the opportunities employees have to understand the way work is developed, as well as the possibilities to learn new job-related skills. The index comprises 14 items organized around the following constructs: the skill content of the job (cognitive dimension), decision latitude, worker participation in the organization, and training. The index shows that skill levels have been increasing in European employees during the last ten years (Parent-Thirion et al., 2016). The index will be denoted as $X_5$ for the mathematical model.
- *Prospects (JQI 6)* The prospects index (JQI 6) combines the indicators of employment status (self-employed or employee), type of contract, and the prospects for career advancement as perceived by the employee. The index comprises 8 items organized under the previously defined construct. The index will be denoted as $X_6$ for the mathematical model.
- *Earnings (JQI 7)* The earning index (JQI 7) measures the monthly earnings of employees. In contrast to the other JQIs, this index is constructed with only one item. The index considers real earnings after tax to capture the portion of the wage that employees have available for use per month. The index will be denoted as $X_7$ for the mathematical model.

### 3.2 The Work Engagement Index

The specialized literature already pointed out the importance of work engagement in improving employees' well-being and sense of personal fulfillment (Bakker and Schaufeli 2015). Furthermore, work engagement is positively related to job performance at an individual level (Bakker et al., 2008). In a similar way, work engagement also has positive implications at a collective level, including commitment to the organization, client satisfaction, good safety records, and employee retention: therefore, the construct contributes significantly to company performance (Bakker et al., 2011). For all of the abovementioned reasons, building work engagement is a key goal of human resource policies and work organization practices.

Finally, it is important to clarify that the work engagement index adopted in this research study is inspired by the EWCS report (Parent-Thirion et al., 2016) and comprises the following five items: (i) *At work I feel full of energy*; (ii) *I am enthusiastic about my job*; (iii) *Time flies when I am working*; (iv) *I feel exhausted at the end of the day* and (v) *I doubt the importance of my work*.

### 3.3 Socio-Demographic Variables

Three socio-demographic variables have also been included in this research study. Specifically, these variables are: (i) the marital status of the employee (with or without a partner), (ii) age and (iii) gender. The socio-demographic variables were not included in the mathematical model because they are not control variables, and therefore, human resources practitioners cannot design human resource policies with respect to those elements. Hence, these variables were included only with the purpose of characterizing the sample.

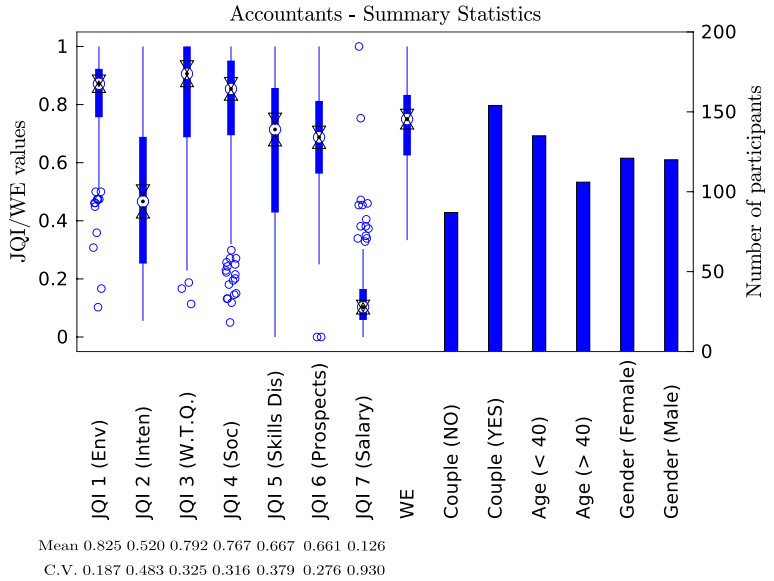


**Fig. 1** Graphical representation of the main characteristics of the accounting-related jobs

## 4 Methodology

The methodology proposed is based on the combination of dimensionality reduction and preprocessing, regression models and a sensitivity analysis (SA) method which has been adapted ad hoc for the research study. In the first step, all of the JQI-related items were included in their corresponding indices, computing after that the final index values as suggested in the sixth European Working Conditions Survey (Parent-Thirion et al., 2016). Furthermore, the sample was preprocessed by removing missing values, and the indices were also scaled to within the same range. In the second step, a regression model for the work engagement estimation problem was implemented using the JQI values for the accountants considered as input variables. Finally, SA was carried out on the best regression model detected in the empirical simulations. The SA allows us to understand the contribution of each of the JQI variables in the work engagement estimation.

### 4.1 Step 1: Dimensionality Reduction and Preprocessing

In the first step, the scores for the different multi-dimensional indices involved in the study (the work engagement index and the seven JQI indices) were computed. To develop an instrument in which results can be compared to state-of-the-art reported results, we decided to adopt the procedure for multi-dimensional indices generation detailed in the sixth EWCS (Parent-Thirion et al., 2016). In this report, both the JQI and work engagement scores are obtained through arithmetic mean aggregation (i.e., all items have the same impact on the construct). Hence, the scores for the involved constructs were computed by averaging the scores of their item values.

After that, accountants with missing values in the constructs were removed, taking into account that the final sample without those employees has a size of 241 elements, which is sufficient to support the significance of the statistical results obtained in the study. In a last stage, all indices were re-scaled to the [0, 1] range using the min-max normalization formula.

The frequency distributions of the socio-demographic (qualitative) variables along with the box-plots associated with the quantitative (numerical) variables (JQI and work engagement indices) are graphically show in Fig. 1. The left y-axis is used to define the scale of the quantitative variables (represented with box plots), and the right y-axis for the qualitative (binary) ones (represented with histograms). In the bottom part of the figure, the mean and the coefficient of variation (CV) for the seven JQI indices are also reported. As seen in Fig. 1, the physical environment index (JQI 1) is the one with the highest mean value and lowest CV. This implies that European accountants have very high JQI 1 and that the values in the index are very homogeneous. Motivated not only by these empirical results but also by the fact that human resources practitioners have little influencing power on this factor in the accounting sector, we decided not to include this factor in the following analyses.

### 4.2 Step 2: Regression Analysis

The goal of regression models is the estimation of instances (cases or examples) on a continuous scale from a set of independent variables. The independent variables in the study are the JQI-related variables. The dependent variable in this research study (the work engagement according to accountants' perceptions) is represented on a quantitative scale, and therefore, the models to be implemented should be the ones classified under the umbrella of regression models. Thus, the regression function of the research study could be defined as $f(X_2, \ldots, X_7) = f(\mathbf{X})$, since the physical environment index has not been included in the analysis.

The most popular approaches for modelling regression problems are the linear regression methods, in which input variables are linearly combined to estimate the hyperplane that best fits the input data according to a specific mathematical criterion (usually the least-squares minimization criteria). These models assume that the input variables are independent and can therefore be linearly combined to estimate the dependent variable.

Neural networks have proven effectiveness in regression analysis under the non-linearity hypothesis. Similarly to linear regression methods, neural networks estimate a hyperplane, but in the basis function space (unlike linear regression methods that are linear in the input space). In the simulations carried out in the study, all tested neural networks are single hidden layer type models. Furthermore, the hidden layers of the models implemented were designed with radial basis functions and sigmoidal units. The model aims at minimizing the regularized least squares error function with two different estimation approaches: the extreme learning machine (ELM) approach and the conventional gradient-based approach (Huang et al., 2006; Fernández-Navarro et al., 2011).

Consequently, the regression models considered in this study are the following: the linear regression (LR) method (the only linear method considered in the experiments), the regression tree (RT), the gradient-based product unit neural network (G-PUNN), the gradient-based radial basis function neural network (G-RBFNN), the gradient-based sigmoidal neural network (G-SNN), the ELM-based product unit neural network (ELM-PUNN), the ELM-based radial basis function neural network (ELM-RBFNN) and the ELM-based sigmoidal neural network (ELM-SNN). In the experiments, the number of hidden nodes,

$S$, in the neural networks models (which defines the final number of parameters, $P$, being $P = K \times S + S$, and $K$ the number of attributes of the problems) has been set in such a way that the number of parameters to be estimated is close to $2N + K$ (where $N$ is the number of training samples). As detailed in Zhang et al. (2017), a simple two-layer neural network with $2N + K$ parameters is capable of fitting any dataset of $N$ samples of dimension $K$. Additionally, the loss functions of those models include in their formulations the Tikhonov regularization term to prevent overfitting. All of the hyperparameters involved in the models tested were estimated by a five-fold nested cross-validation procedure using the range values proposed by the corresponding authors.

### 4.3 Step 3: Sensitivity Analysis

Neural network models are considered "black-boxes" because they are able to find "hidden" relations between inputs and the dependent variable with a high approximation ability, but do not provide any knowledge regarding their internal functioning (for example, the main effects of the input variables on the output are unknown). Social scientists are usually dissatisfied with "black-box" models because they typically require additional knowledge from the model to discuss their findings (López-Iturriaga and Sanz 2018). For example, in this research study, it is crucial to quantify the impact of the JQI-related variables on the work engagement scores or to discover which JQI constructs have the highest influence on the final work engagement score.

SA is one of the methods used to understand the internal functioning of non-linear mathematical machine learning models. It acknowledges the "black-box" nature of those models by studying the direct effects that inputs have on classification or regression outputs. SA has conventionally been applied in the field of machine learning using local sensitivity analysis (LSA) techniques (Kewley et al., 2000; Pérez-Barea et al., 2018). LSA involves taking the partial derivatives of the model output with respect to their input variables. The main limitations of LSA techniques are that: (i) they only analyse the behaviour of the model in the immediate region around the optimum determined during the parameter estimation, and (ii) they only consider changes to one or a few parameters at a time.

Motivated by these facts, we propose an alternative way of measuring the sensitivity indices in regression problems using Sobol decomposition (Sobol, 2001) (a global sensitivity analysis (GSA) technique based on the ANOVA decomposition), which overcomes the previously mentioned limitations. The proposed method determines the importance of each input variable by taking into account the variance provided by the parameter to the total variance of the output (Sobol 2001). The regression functions are decomposed as proposed by Sobol (2001). In our case, the regression function $f(\mathbf{X})$ is decomposed in the following way (for the first-order decomposition)[3]:

$$f(\mathbf{X}) = f_{X_2}(X_2) + \ldots + f_{X_7}(X_7) + R(X_2, \ldots, X_7), \tag{1}$$

This functional decomposition allows us to divide the variability of the function into several parts, including those of the input variables (represented by the first summands) and the non-separable effects of those input variables (the interaction effects which are included in the last term). A detailed description of the algorithm for nominal classification problems can be found in Fernández-Navarro et al. (2016). In this study, the method has been

[3] The second-order decomposition also includes the interactions by pairs of the input variables.

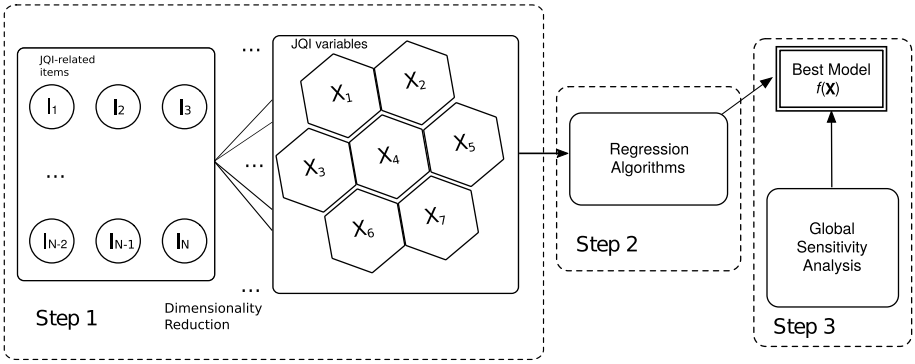


**Fig. 2** Different steps involved in the development of the proposed index

**Table 1** Generalization results of the RMSEP of the machine learning methods along with the p-values of the Wilcoxon rank sum test. The symbol ⋆ is used to denote that the null hypothesis, through the results provided by the comparison method and the results of ELM-SNN are samples with equal medians, is rejected

| | Work engagement estimation | |
|---|---|---|
| | RMSEP | *p*-value RMSEP |
| LR | $0.2849_{0.0387}$ | 1.8E-4⋆ |
| RT | $0.2310_{0.0179}$ | 1.8E-4⋆ |
| G-PUNN | $0.1822_{0.0251}$ | 0.0351⋆ |
| G-RBFNN | $0.1911_{0.0413}$ | 1.8E-4⋆ |
| G-SNN | $0.1700_{0.0199}$ | 0.0713 |
| ELM-PUNN | $0.2277_{0.0283}$ | 1.8E-4⋆ |
| ELM-RBFNN | $0.2130_{0.0290}$ | 1.8E-4⋆ |
| ELM-SNN | $0.1521_{0.0381}$ | – |

adapted to the regression scenario. Finally, Fig. 2 presents a schematic view of the steps of the methodology and the associated models. The best mathematical model (with the best accuracy reported) is presented in a double squared box.

## 5 Results

This section presents the experimental study performed to validate the non-linear regression methods presented in Section 4. The different machine learning approaches were evaluated according to the root mean square error percentage (RMSEP) metric, and the hyperparameters of these methods were tuned by Bayesian optimization using the grids suggested by the corresponding authors. We adopted a 10-fold cross-validation (with 3 repetitions per fold) in the experimental study aiming to statistically assess how the machine learning models generalize out-of-sample data. Table 1 shows the overall generalization results and standard deviations obtained with the different implemented methods. Furthermore, each pair of methods was compared by means of the Wilcoxon test for $\alpha = 0.05$, considering the ELM-SNN method as the control method (since it produced the best mean ranking for the empirical data considered).

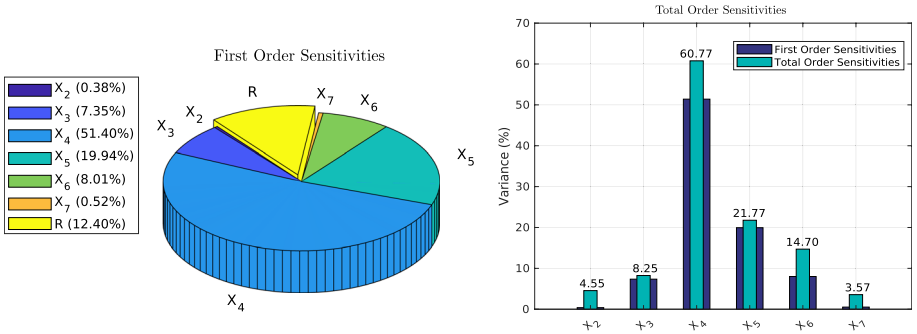


**Fig. 3** Pie chart with the first-order sensitivity indices and histogram with the total-order sensitivity values

A purely descriptive analysis of the results reveals that: (i) the ELM-SNN method achieved the best results in the generalization set (with an overall RMSEP of 0.1521), and (ii) the second best result was obtained in most of the cases by the G-SNN method (with an overall RMSEP of 0.1700). In addition, as shown in Table 1, the ELM-SNN method achieved significantly better results than the remaining methods, except the G-SNN method. Finally, as can be observed, the linear regression (LR) model is not able to reflect nonlinear relationships among input variables, which is necessary for performing a competitive estimation task.

The sensitivity analysis method proposed was applied on the ELM-SNN method (as it was the best performing non-linear regression model). The proposed procedure aims at determining the influence of each job quality variable in the work engagement estimation. The ELM-SNN method on the first fold will be considered and analysed in this Section. Figure 3 shows the sensitivity results obtained from the ELM-SNN model for the first- and total-order indices, respectively. In this way, two types of sensitivity indices are studied:

- First-order sensitivity indices, which determine the contribution to the output variance of the main effect of the $i$-th input variable.
- Total-order sensitivity indices, which quantify the contribution to the output variance of each variable considering its main effect and its interactions with other input variables.

The left part of Fig. 3 represents the first-order sensitivity indices obtained after analysing the selected machine learning model (the ELM-SNN method). The variable that contributes the most in the explanation of the output variance is the social environment variable ($X_4$, 51.40%), followed by variables associated with the skill use and discretion ($X_5$), prospect ($X_6$) and work time quality ($X_3$) that explain 19.94%, 8.01% and 7.35% of the output variance, respectively. It is important to mention that the output variance of the work engagement construct is almost not influenced by the earning ($X_7$) and work intensity ($X_2$) variables (as they only explain 0.52% and 0.38% of the output variance). Finally, 12.40% of the variance of the output is explained by the interactions among the input variables (those higher-order interactions are denoted as R in the left part of Fig. 3).

The right part of Fig. 3 represents the total-order sensitivity indices obtained for the best performing machine learning model (the ELM-SNN method). As can be observed in Fig. 3, the job quality components with more interactions with other input variables are the social environment and prospect variables.

## 6 Discussion

This paper aims at identifying the dimensions of the job quality that contribute the most to higher work engagement levels. This objective is addressed by quantifying how the different dimensions of the Job Quality Index (JQI) influence the output variance of the work engagement construct. For this purpose, a nonlinear regression model (neural network based) that relates job quality components with the work engagement construct was implemented, and the influences of the job quality components on the work engagement were evaluated according to a recently proposed global sensitivity method.

First, it is important to stress that the competitive performance achieved by the proposed method (the ELM-SNN algorithm) allows us to claim that the work engagement in the accountancy sector can be partially explained through non-linear combinations of the components of the job quality multi-dimensional construct. Hence, accountancy firms and accounting departments could develop human resources strategies for improving work engagement in the employees by promoting the components of the job quality multi-dimensional index.

An accountant's activity is characterized by vigorous work intensity (due to tight deadlines) (Pierce & Sweeney, 2004) and high competition among the staff (that adjusts the number of hours employed to perform the audit work even more) (Otley and Pierce, 1996; Willett & Page, 1996; Sikka, 2004). This is mainly because accounting firms are organized with structured teams which are oriented to the achievement of objectives (Covaleski et al., 1998). As shown in our empirical results, the most effective strategy for improving work engagement amid difficult working conditions should rely on developing human resource policies that promote social support among peers and superiors with optimal training courses to enhance the accountants' skills, along with offering clear career prospects. Unfortunately, in some audit activities, it is not always possible to implement such human resource policies due to the tight deadlines of the audit work.

The importance of the development of the social dimension for improving job satisfaction, engagement and performance was already pointed out by Bakker et al. (2011), among others (Vera et al., 2016). As expected, these results were also observed in the accountancy sector (Herda & Lavelle, 2012; Cannon & Herda, 2016). In this way, a highly competitive organizational culture with stringent and arrogant superiors would negatively affect the positive perception about social support, and, unfortunately, this type of working environment is highly common in conventional audit firms (Ussahawanitchakit, 2008). Hence, a better workplace climate, better well-being of professionals and a greater feeling of belonging are positively correlated to the work engagement associated with the employees of the audit firm (Umans et al., 2016).

The level of work engagement is almost independent of the assessment of work intensity and salaries. Previous research has identified that burnout and dysfunctional audit behaviour (Fogarty et al., 2000; Sweeney & Summers, 2002) are more likely to occur with higher job demands; however, this negative correlation among work intensity and job satisfaction or work engagement is not significant in the case of the audit work (as shown in the previously reported empirical results). This can be because accountants assume the stressful setting associated with this job from the very beginning. Therefore, the adverse effects of work intensity on job satisfaction and turnover intentions might be cushioned through a strong social support network, professional growth and the promise of career development.

The challenging work of accounting requires self-efficacious individuals who work on teams and find satisfaction in achieving objectives. These professionals could find work

intensity to be a positive stressor that reinforces the engagement if they are able to work on teams, challenging their capabilities and being fairly recognized by the organization (Parker and Kohlmeyer III 2005). Many professionals join accountancy firms because they consider the opportunity as a highly stimulating activity which is a successful start for career development (Umar et al., 2017).

The interaction between the dimensions reveals that social support and career prospects explain a great deal of the 12% of the work engagement variance associated with higher-order sensitivity indices. A team working philosophy offers organizational justice and the challenge of fair individual recognition, and it is inversely related to burnout (Herda & Lavelle, 2012; Cannon & Herda, 2016). For this reason, human resources strategies must pursue promoting teamwork and career development for promoting work engagement.

## 7 Conclusions

This study is the first attempt to explore the relationship among work engagement and job quality in the accountancy sector following a holistic approach. Contrary to the expectation that auditors adopt an individualistic approach to their work, this study clarifies that auditors feel well when working on teams and consider the social support of their peers and superiors, and the lack of adverse social behaviour, to be crucial. Furthermore, this study also presents to the managerial auditing community that the audit employee's expectation of career opportunities and the development of accountant skills are also key variables that moderate the work engagement construct. The instrument implemented could be employed by human resources practitioners to propose efficient human resources strategies that improve both individual well-being and company performance in the accounting sector.

It is necessary to mention the major methodological limitations of this study. First, perceived work engagement and job quality were evaluated through individual self-perceptions. Second, the problem of social desirability is a setback to studies that ask about how labour conditions affect employees. Self-perception and social desirability may cause bias in responses. Third, the relationship between the variables being investigated cannot be considered causally because we studied cross-sectional data, not experimental data. Four, the job quality variables may be influenced by country/cultural issues. Thus, we will study in future research the feasibility (due to the sample size of the study) of including cultural variables in the theoretical framework proposed. The inclusion of those elements in the model will allow us to analyze their impact in the work engagement construct, as well as their influence on the job quality dimensions. Finally, the study is limited to the scope of the European Union. Future studies should investigate the influence of the model implemented with respect to professional accountants who develop their activities in other cultural contexts.

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