**THE REPUBLIC OF TURKEY**
**İSTANBUL KÜLTÜR UNIVERSITY**
**INSTITUTE OF GRADUATE STUDIES**

# THE IMPACT OF COVID-19 PANDEMIC ON THE ENGINEERS' PERFORMANCE

**MASTER OF SCIENCE THESIS**

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**Department: Industrial Engineering**

**Program: Engineering Management**

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**JUNE 2022**

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**Omar Yahya Mohammed Al-Kaff**

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Humbly and proudly, I represent this study for the memory of my role-model in life, my beloved father who left this life during the journey but never left and will never leave my heart, mind, and soul. Also, I represent this research as a token gift for my precious mother and my dear family who always supported me during my expatriation.

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## LIST OF SYMBOLS

| | |
|---|---|
| **AVE** | Average Variance Extracted |
| **CB-SEM** | Covariance Based SEM |
| **CCA** | Confirmatory Composite Analysis |
| **CFA** | Confirmatory Factor Analysis |
| **COVID-19** | Corona Virus of 2019 |
| **CR** | Composite Reliability |
| **EFA** | Exploratory Factor Analysis |
| **EP** | Engineers' Performance |
| **$f^2$** | Effect Size |
| **GoF** | Goodness of Fit |
| **H** | Hypothesis |
| **HCCA** | Hair's Confirmatory Composite Analysis |
| **HTMT** | Heterotrait - Monotrait Ratio of Correlations |
| **JS** | Job Satisfaction |
| **K** | PLSpredict Subgroup |
| **LM** | Linear Regression Model Prediction Errors |
| **MAE** | Mean Absolute Error |
| **ML** | Maximum Likelihood Theory |
| **MLR** | Robust Maximum Likelihood Theory |

| | |
|---|---|
| **OC** | Organizational Changes |
| **PLS-SEM** | Partial Least Square SEM |
| **Q** | Question |
| **$Q^2$** | Stone-Geisser's Value |
| **$Q^2$predict** | Stone-Geisser's Value of PLSpredict Algorithm. |
| **$R^2$** | Coefficient of Determination |
| **RMSE** | Root Mean Square Error |
| **S** | Stress |
| **SEM** | Structural Equation Modeling |
| **VIF** | Variance Inflated Factor |
| **WLB** | Work – Life Balance |
| **WLSMV** | Diagonally Weighted Least Square |

**Üniversite** : **İstanbul Kültür Üniversitesi**

**Enstitü** : **Lisansüstü Eğitim Enstitüsü**

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**Programı** : **Mühendislik Yönetimi**

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# ÖZET

## COVID 19 PANDEMİSİNİN MÜHENDİSLERİN PERFORMANSI ÜZERİNDEKİ ETKİLERİ

**Omar AL-Kaff**

COVID-19 krizi sırasında, çok sayıda çalışma, kurumsal başarının önemli bir belirleyici faktörü olarak çalışan performansını araştırırken, aksine, kritik rollerine ve artan sorumluluklarına rağmen mühendislerin performansına dikkat çekici bir odaklanma olmadı. Dolayısıyla bu araştırma, COVID-19 pandemisinin mühendislerin performansı üzerindeki etkisini incelemek üzere başlatılmıştır. 100 mühendisten gelen anket verileri *Kısmi En Küçük Kareler Yapısal Eşitlik Modellemesi* (PLS-SEM) kullanılarak analiz edilmiş, ayrıca yakın zamanda önerilen *Doğrulayıcı Bileşik Analiz* (HCCA) yöntemi kullanılarak oluşturulan modelin güvenilirliği ve geçerliliği sağlanmıştır. Sonuçlar, *Organizasyonel Değişim, İş-Yaşam Dengesi, İş Memnuniyeti* ve *Stres* aracı değişkenleri aracılığıyla COVID-19 pandemisinin mühendislerin performansı üzerinde olumlu etkisi olduğunu ortaya koymaktadır. Yaşadıkları stres düzeyinin, beklenenin aksine performansı arttırdığı bulunmuştur ki muhtemelen bu sonuç felaketin ortasında bile performans iyileştirmeleri yaratmayı sağlayan başarılı yönetim uygulamalarına işaret etmektedir. *Cinsiyet, İş Deneyimi, Çocukların Sorumluluğu* ve *Medeni Durum* kontrol değişkenleri ayrıca incelenmiş, daha deneyimli ve evli olmayan mühendislerin diğerlerine göre nispeten daha yüksek performans gösterdikleri görülmüştür.

**Anahtar Kelimeler:** *COVID-19, Mühendis Performansı, Kısmi En Küçük Kareler Yapısal Eşitlik Modellemesi (PLS-SEM), Hair Doğrulayıcı Bileşik Analiz (HCCA)*

**University** : **İstanbul Kültür University**

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# ABSTRACT

## THE IMPACT OF COVID-19 PANDEMIC ON THE ENGINEERS' PERFORMANCE

**Omar Yahya Mohammed Al-Kaff**

During COVID-19 crisis, numerous studies have investigated employee's performance as a major determinant factor of organizational success. In such hard times, there was no noticeable focus on engineers' performance despite their critical roles and increased responsibilities. Thus, this research is initiated to study the impact of COVID-19 pandemic on engineers' performance. Survey data from 100 engineers have been analyzed using Partial Least Square Structural Equation Modeling (PLS-SEM), also reliability and validity of the constructed model have been ensured using a recently proposed new *Confirmatory Composite Analysis* method (HCCA). Path model results suggest a total positive impact of COVID-19 pandemic on engineers' performance through *Organizational Change, Work-Life Balance, Job Satisfaction and Stress as* mediators. The level of their experienced stress has been found to increase the performance rather than the opposite, which probably indicates successful management implementations that enabled creating performance improvements even amid the catastrophe. Control variables of *Gender, Work Experience, Responsibility of Children, and Marital Status* are additionally examined, and more experienced and non-married engineers have been observed to have relatively increased performance than others.

**Keywords:** *COVID-19, Engineers' Performance, Partial Least Square Structural Equation Modeling* (PLS-SEM)*, Hair's Confirmatory Composite* Analysis (HCCA)

# 1. INTRODUCTION

The employees' performance is a critical major factor of success in any organization (Indermun & Bayat, 2013, as cited in Elnaga & Imran, 2013), especially when the employees are responsible of taking or performing critical decisions and executions, which probably is the case for engineers. Assessment of the workforce performance is an important management tool that helps the organizations assessing the employees' contribution suitability to reach the organization goals (Fekete & Rozenberg, 2014). During the recent Corona Virus of 2019 (COVID-19) pandemic many questions have raised about its impact on organizations and businesses since it is obviously affected the economics and the social-life. One of these questions concerns about the impact of the COVID-19 pandemic on the employees' performance after the changes in the working environments resulted from the preventative actions taken against the virus spread. Probably many companies applied the online-working method, and mostly all the organizations have taken the social-distance into consideration beside other preventive actions and decisions. Related to the previous concern, Bustamam (2020) believed that the employees as a human-beings are influenced by their emotional and psychological aspects, and the balance between the life activities and their work play a major role on their performance. These sudden changes due to the pandemic, economical and health risks, and the sudden changes in the social life activities in general, may have affected the engineers psychologically which has affected their performance as consequence.

The main objective of this research is investigating the impact of COVID-19 pandemic on the Engineers' Performance (EP), that implicate sub objectives to achieve which are:

1- Proposing factors which may relate the Pandemic with the engineers' performance.
2- Constructing a valid and reliable model that relates the COVID-19 crisis with the engineer's performance.

3- Testing the hypotheses with the data collected by an originally developed questionnaire.

The factors that are suggested in the literature to impact the employees' performance in general and possibly may have a connection with the COVID-19 widespread are identified for this study as: Organizational Changes (OC), Work – Life Balance (WLB), Job Satisfaction (JS), and Stress (S).

Toward achieving the research goals, the following questions (Q) are developed that help to understand the targeted information to construct the hypotheses.

Q1: What is the relationship between the COVID-19 pandemic and the Engineers' Performance

Q2: What is the relationship between the Organizational Change and the Engineers' Performance?

Q3: What is the relationship between the Work – Life Balance and the Engineers' Performance?

Q4: What is the relationship between the Job Satisfaction and the Engineers' Performance?

Q5: What is the relationship between the Anxiety/Stress and the Engineers' Performance?

According to the previous questions with the sight of the literature information and assumptions, 10 hypotheses (H) and a relationship model have been proposed as following:

H1: COVID-19 Pandemic increases Organizational Changes.

H2: Organizational Changes impacts job satisfaction negatively.

H3: Organizational Changes increase engineers' Stress directly.

H4: Organizational Changes decrease Work-life balance directly.

H5: Work – Life Balance has a direct positive impact on engineers' performance.

H6: Work – Life Balance decreases Stress directly.

H7: Work – Life Balance increases job satisfaction directly.

H8: Stress decreases job satisfaction directly.

H9: Stress has a direct negative impact on engineers' performance.

H10: Job satisfaction increases engineers' performance directly.

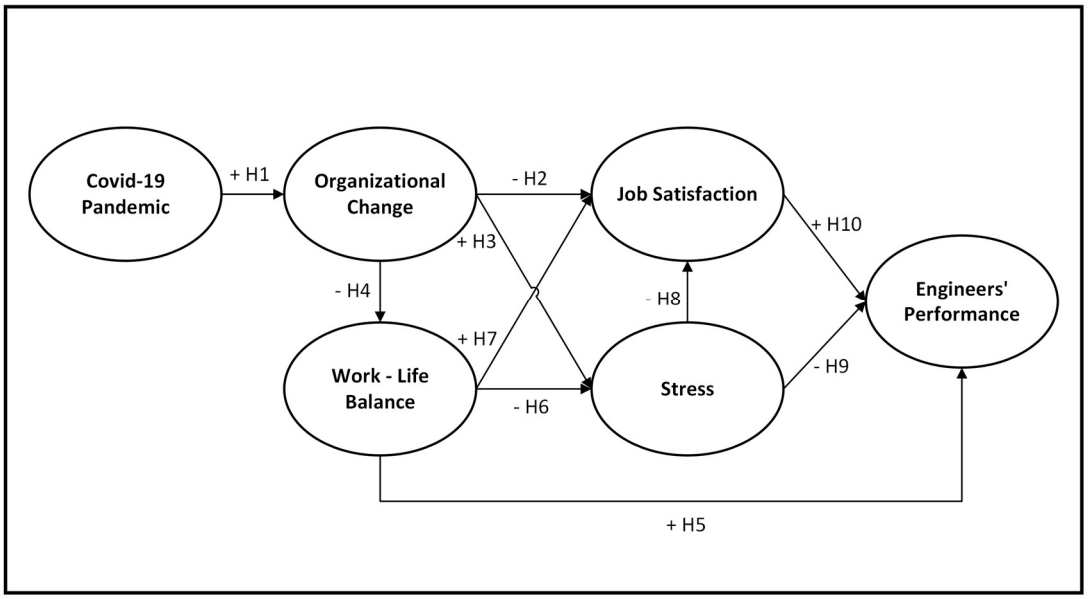


**Figure 1.1** Structural model of the factors' relationship with engineers' performance.

figure 1.1 represents the constructed model using the developed hypotheses and demonstrates the nature of the hypothesized relation between the factors and performance, the (+) and (-) signs stand for a positive and negative relationship respectively.

The significance of this research may present in connecting the extraordinary new case of COVID-19 and its effect on the engineers' performance by providing a reliable valid model that relate probable effective factors in such pandemics, which may enrich the literature information by providing valuable experience for similar future situations.

Toward accomplishing the research goals, five sections have been created and represented in this research as following:

Introduction: This section provides an overview of the research topic; states the research goals, questions, and hypotheses; presents the structural model and highlights the significance of the research.

Literature Review: Displays some previous implementations summary related to the research topic to gather some factors and effects information, then demonstrate the factors selection and hypotheses construction supports of this research.

Methodology: the most important aspects of SEM method to this study like assumptions, steps, and measures information which used in this research have been discussed briefly in this section.

Implementation and Results: research results and findings information have been demonstrated in this part.

Conclusion: Summarizes the research goals and what have been achieved through the study, also declares some of this research limitations along with possible recommendations for future studies.

## 2. LITERATURE REVIEW

Throughout the literature there are no significant focus on the impact of COVID-19 pandemic relevant to engineers' performance, though almost all the literature research considers the employees performance topic, each in its specific industry as a workforce assessment tool. Generally, many factors proposed in the literature to have a direct or indirect effect on the employees' performance, and most probably their importance varies from case to another and between different organizations and situations. For instance, among the high number of factors, Alefari et al. (2020), believe that three main factors directly affect the employees' performance and covers other intermediates factors, which are the employee health or thriving, encouragement, and capability. figure 2.1 shows the frequency of the factors through the literature since last decade, and the most frequent mentioned factors are leadership style, organizational culture, employee wellbeing, and training; while the least frequent are flexible working arrangement, work-life balance, career development, and external environment (Alefari et al., 2020).

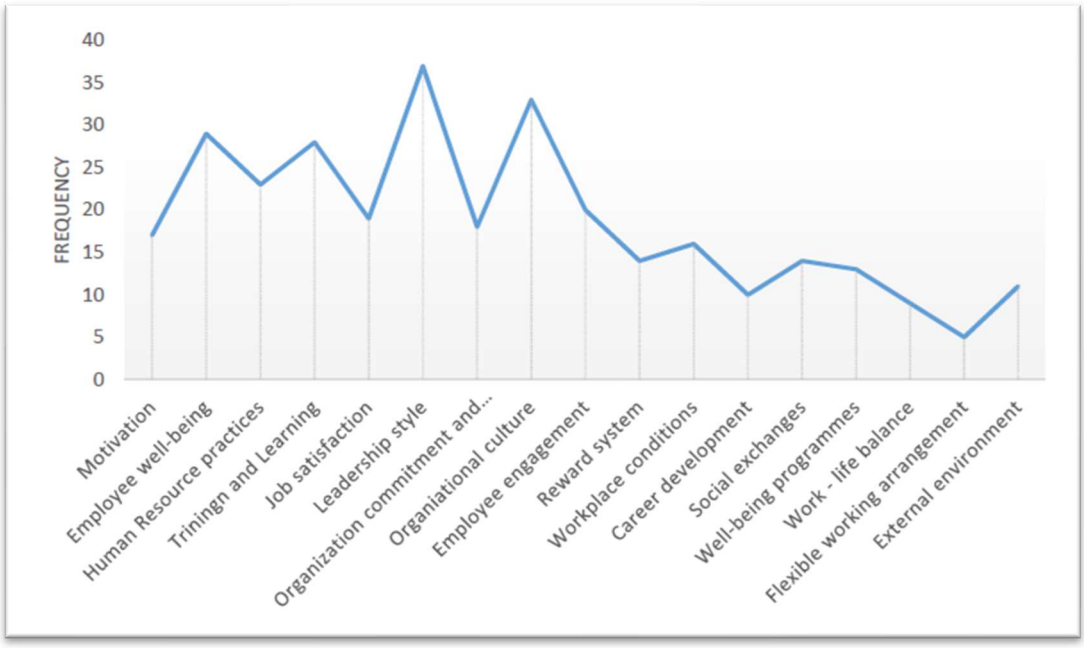


**Figure 2.1** Frequency of factors effecting performance mentioned in the literature (Alefari et al., 2020)

At instant, majority of the studies concentrate on specific factors to investigate employee's performance relationship under normal circumstances, and studies on the

effect of previous extraordinary conditions (ex. crises) are rare. Some encountered studies which focus on the effect of factors under extraordinary conditions like the COVID-19 pandemic and gathers the most frequent factors have been summarized under this section.

In services business sector, Narayanamurthy and Tortorella (2021) argue about the changes occurred in that type of business specifically to the employees in the time of COVID-19 outbreak. Factors as the virtual communicating, work infrastructures in homes, and the employees job insecurity suggested to have some effect on the workers' performance in addition to the mediating effect of Industry 4.0 practices. Workers' performance has been described by two descriptors: the workers job quality, and the time manner quality or delivery rate of the workers; Surveys distributed among more than one hundred workers different services companies, examine the pervious propositions. The result show that the home/work infrastructure affects both the work quality and delivery positively. 'Virtual Communication' and 'Job Insecurity' show relatively no significant influence, although the virtual communication show a positive effect on both parts of performance but with less impact comparing to the home infrastructure effect. In addition, results propose positive moderating impact of the industry 4.0 tools on the relationship between the online communication and the performance, and negative effect on the relationships of the home infrastructure and job concerns with the workers' performance (Narayanamurthy & Tortorella, 2021)

Kumar et al. (2021), explore the effects of some variables which suggested to be aroused by COVID-19 Pandemic, on the factors of employee's work performance and anxiety where these both factors impact employees' life satisfaction in different India located companies. The tested variables are the overloaded work, personal life options, family interruption, and work difficulties. Personal life options are mostly minimized during the COVID-19 crisis, because of the precaution actions there is not many choices of life activities available as before. Family interruption mainly occurs with the remote working from homes so the family shared responsibilities or family activities may affect worker ability or performance, and work difficulties caused by the lack of previous experience or adaptation of the visual work practices in the most of India located companies before the crisis (Kumar et.al., 2021). Survey data collected from around 430 respondents with 36 items indicate that both 'Work Overload' and

‘Personal Life’ options have no significant impact on the employee’s job performance, while results of ‘Family Interruption’, ‘Work Difficulties’, and ‘Anxiety’ show the greater negative impact on the employee’s work performance, and anxiety dominates these variables in the effect intensity. Kumar et al. (2020) suggests considering ‘Work-Life Balance’ factor to the future research.

Koekemoer et al. (2021) research concern about the relationship of leadership adaptability, team efficiency, technological resilience, work commitment, and employee’s performance during the COVID-19 endemic and the preventive actions that have been taken in South Africa because of the widespread as the home isolation which may have an impact on the previous relationship. To explain the variables, the ‘Leadership Adaptability’ variable mainly concerns about the leaders’ behavior in the pandemic and their responsiveness to change, ‘Team Efficiency’ variable is about the willingness of the individual members of the working teams to help each other and collaborate, ‘Technological Resilience’ express the flexibility given to the employees to work virtually or homely, ‘Work Commitment’ indicates the obligation and the sense of responsibility of the worker towards his job, Finally the ‘Job Performance’ as the main outcome variable have been described by three means as following, the capability to perform a certain task proficiently, proficiency, the flexibility or adaptability to change ‘adaptivity’, and the initiation of workers in challengeable situations toward the change ‘proactivity’ (Koekemoer et al., 2021). To assess the constructed model, a survey of about 29 items with a Likert scale divided between the variables has been provided and collected from around 230 employees, and the results suggest the weakness or inexistence of leadership attitude direct effects on employee’s performance. On the contrary, it also suggests the existence of moderate positive effect of leadership attitude on the work commitment. In a similar manner of leadership attitude results, the team efficiency results do not support the direct relationship with the performance but support the positive relationship with the work commitment. Technological resilience outcomes only recommend the positive direct effect on one term of worker’s performance which is the adaptivity and disprove the other effects. The case of work commitment which may relate the previous variables with the performance propose the positive impact on two of the performance terms adaptivity and proactivity. Which mean both leadership attitude and team efficiency variables may probably affect the employee’s performance (adaptivity, and proactivity) through

the work commitment as a mediating varible. Koekemoer et al. (2021) proposes exploring psychological and social related impacts of COVID-19 pandemic.

Suratman et al. (2021) investigate the impact of 'Psychological Climate', 'Self-Resilience', 'Organizational Citizenship Behavior', and 'Work Stress' on the workforce performance during the corona epidemic using survey responses of more than three hundred workers of different companies in Indonesia. 'Psychological Climate' describe the effect of the workplace climate on the worker feeling of security and capability which probably may encourage or discourage the worker toward his job, 'Self-Resilience' means the employee's ability to withstand the challengeable situations and his willingness to adapt the changes in the work conditions, 'Organizational Citizenship Behavior' is the worker's loyalty and dedication to his organization, 'Work Stress' is related to the anxiety that may occur to the worker due some kinds of stressors or obstacles in the work. Furthermore, Suratman et al. (2021) outcomes provide unfavorable significancy values except for the negative effect of Self-Resilience on Work Stress, and the direct positive effect of Psychological Climate on the employee's performance.

Quintana et al. (2021) explores the role of 'Job Insecurity' on employee's 'Task Performance' through 'Anxiety', 'Depression', and the mediating effect of 'Resilience' on performance and the other factors, in COVID-19 widespread time. Resilience may be demonstrated as the worker's ability to cope the changes or withstand hard conditions. Surveys outcomes of twenty-eight items applied on approximately 350 hotel employees in Spain, hint that Job Insecurity directly and insignificantly decreases the employee's job performance, and significantly impact employee's stress and sadness positively; Resilience suggested to enhance worker's job performance. Furthermore, the results reject all impacts of job insecurity, anxiety, and depression on the employee's task performance which indicates that the work performance of that hotel employees targeted segment have not been influenced by the factors presented in this research (Quintana et al., 2021). Outcomes hint that job insecurity directly and insignificantly decreases the employee's job performance, and significantly impact employee's stress and sadness positively; resilience suggested to enhance worker's work performance. furthermore, the results reject all impacts of job insecurity, anxiety, and depression on the employee's task performance which

indicates that the work performance of that hotel employees targeted segment have not been influenced by the factors presented in this research. Additionally, Quintana et al. (2021) recommends investigating organization related factors' effects on employee's performance.

Erer (2020) believes that COVID-19 crisis exerts a sort of 'Anxiety and Fear' on the employees, and these influences probably decreases the workers' performance. However, this research focuses on COVID-19 Fear and its relationship with the employee's performance. The investigation has been applied on food baking industry located in Turkish Konya city, two hundred and thirty survey replies have been collected, and result propose a negative moderate impact of COVID-19 fear on employee's performance.

Aropah et al. (2020) examines three factors suspected to have some probable effect on workers' performance during COVID-19 widespread which are 'Transformational Leadership', 'Work Environment', and 'Organizational Support'. The expletory research has been performed on 128 workers in the National Public Procurement Agency in Indonesia. Aropah et al. (2020) defines the 'Organizational Support' as the technological resources provided by the management department as infrastructure or financial support; 'Transformational Leadership' factor as the efficiency of the leader to direct and support workers in the difficult circumstances; and 'Work Environment' as the degree of suitability of the home's infrastructure to perform the required work. Transformational leadership result supports the positive impact on workers' performance. Organizational support result has been dropped due to unreliability, while work environment result suggests positive impact on workers' performance and proposes the highest effect between the factors.

In the time of COVID-19 pandemic, Susilo (2020) considers the impact of 'Home Working' on employees' work performance with 'Work Environment', 'Job Satisfaction', and 'Work Motivation' as intermediate variables. Processed surveys data of more than 300 respondents collected online in Indonesia represent indication of indirect positive home working impact on work performance through work environment, work motivation, and job satisfaction.

Novitasari et.al. (2020) studies the 'Work-Family Conflict' impact on workers' performance, and 'Readiness to Change' as an intermediate factor in the time of

COVID-19 epidemic. More than 140 respondents survey data have been extracted from wrapping company in Indonesia. 'Work-Family Conflict' is defined with conflicting responsibilities of the family and the work due to work overload or inadequate work scheduling, so the work may be an obstacle on family life activities or obligations fulfillment which probably affects the employee's satisfaction, motivation, and performance. While the 'Readiness to Change' factor describes the worker attitude toward changes. The results suggest negative impact of work-family conflict on employee's performance, positive impact of work-family conflict on readiness to change, positive effect of readiness to change on employee's performance, and positive impact of work-family conflict on employee's performance through readiness to change. table 2.1 summarizes factors of the previous implemented studies discussed above, and spotlights on some factors that have been recommended to further research.

Regarding factor selection and hypotheses construction, choosing factors depending on the frequency of measurement in the previous research may support the success probability of the hypothesized relationships, but from another perspective measurement frequency may highlight gaps of untested factors or relationships in the literature research which can be filled. Thus, the factors in this research have been chosen considering the more likely differentiable factors during the epidemic beside the frequency. The major concerns concluded from table 2.1 are about the work-related changes and the employee's psychological state which both concepts have been represented in this research by "Organizational Changes", "Job Satisfaction", and "Stress".

As explained by Bicer (2021), *organizational change* is any decision taken by the organization that make changes in the working method, technology, organization formation, or strategy. Bicer (2021), discusses that the reasons behind making organizational changes are to solve existing problems caused by external or internal factors, make improvements in a certain business, and adapt to compete in the rapid changing business world. so probably most of the organizations during COVID-19 makes organizational changes to survive and cope with this critical unique situation and its related problems. Furthermore, Koekemoer et al. (2021) recommends

additional investigation about organizational factors' effect on performance which support the "Organizational Changes" election for examination.

**Table 2.1** Factors explored in the literature during COVID-19 pandemic.

| Research | Factors | Recommended Factors |
|---|---|---|
| Narayanamurthy & Tortorella (2021) | - Home/Work Infrastructure *<br>- Job Insecurity<br>- Online Working * | |
| Kumar, et.al. (2020) | -Family Interruption *<br>-Work Difficulties *<br>-Anxiety *<br>-Work Overload<br>-Personal Life Options | - ***Work-Life Balance*** |
| Koekemoer et al. (2021) | - Leadership Adaptability *<br>- Team Efficiency *<br>- Work Commitment<br>- Technological Resilience | |
| Suratman et al. (2021) | -Psychological Climate *<br>-Self-Resilience *<br>-Organizational Citizenship Behavior<br>-***Work Stress*** * | |
| Quintana et al. (2021) | -Anxiety<br>-Depression<br>-Resilience * | -***Organization related factors*** |
| Erer (2020) | -COVID-19 Fear * | |
| Aropah et al. (2020) | -Transformational Leadership *<br>-Work Environment *<br>-Organizational Support | |
| Susilo (2020) | -Home Working *<br>-Work Environment *<br>-Motivation *<br>-***Job Satisfaction*** * | |
| Novitasari et.al. (2020) | -Work-Family Conflict *<br>-Readiness to Change * | |

**(*)** The factor has been suggested to effect employees' performance within the related research scope.
***Bolded factors*** highlight some adapted concepts in the study.

*Job satisfaction* can be demonstrated as the employees' behaviors, emotions, and perspectives regarding the work. (Armsrong, 2017, as cited in Došenović & Todorović, 2021), and a psychological reaction arises from different work features or situations. (Kinicki & Fugate, 2016, as cited in Došenović & Todorović, 2021). Susilo (2020) supports the effect of "Job Satisfaction" on worker's performance.

*Work-Life Balance* factor can be described as the balance between the work and life obligations in which avoiding or decreasing the conflict between employee's job and personal life may increase employee's satisfaction and productivity (Lim & Misra, 2019). Alefari et al. (2020), claimed that *Work-Life balance* is one of the least frequent *employees' performance* factors in the research area, which offer a research enrichment opportunity. Furthermore, Work-Life balance factors gathers two subjects that probably have been changed or affected during COVID-19 crisis which are social/personal life and work. For these reasons "Work-Life Balance" factor has been elected in this research. Generally, the hypotheses have been constructed upon the literature suggestions as represented in this section. Also, Kumar, et.al. (2020) propose Work-Life balance factor for further exploration.

After choosing these factors, the following 10 hypotheses have been developed for research. These are constructed based on the proposals of the previous research as given below.

**H1: COVID-19 Pandemic increases Organizational Changes.**

Almost globally, Transformational *organizational change* has been a mandatory action taken by businesses to survive and cope during COVID-19 pandemic (Amis & Greenwood, 2020)

**H2: The Organizational Changes impact the job satisfaction negatively.**

**H8: Stress decreases job satisfaction**

Hayajneh et al. (2021) discuss the effect possibilities of *organizational changes* that direct positive impact of organizational changes on employees' *job satisfaction* is one expected impact, also organizational changes may increase employees' *stress* which lead to decreased *job satisfaction*; and these opposite paths of influence may lead to increase or decrease the *job satisfaction*. In contrast, Seymour et al. (2017) claims the

decreasing *job satisfaction* in the time of major *organizational changes*. Irawanto et al. (2021) supports the negative impact of *stress* on *job satisfaction*, and Saifer et al. (1995) believes that increasing the extent of *organizational changes* and worker's *stress* decreases employees' job satisfaction.

**H3: The Organizational Changes increases engineers' Stress.**

Halkos and Dimitrios (2012) discusses that *organizational change*s may escalate employees' *stress*, but when employees develop the clear understanding of the reasons and goals behind the implemented changes their performance may increase. The most observable consequence of *organizational changes* is increasing *stress* among the workers (Wisse & Sleebos, 2016).

**H4: The Organizational Changes decreases Work-life balance.**

Shobitha and Sudarsan (2018) explore the factors that may influence the *Work-life balance*, and states that number of organizational factors suggested in the literature to affect the Work-life balance, which are work arrangements, work overload, technological changes, and Work-life balance policies. Supporting the existence possibility of *organizational changes* relationship with *Work-Life balance*, the factors work arrangements and work overload mentioned by (Shobitha & Sudarsan, 2018) may be included under organizational changes taken during COVID-19 pandemic, and the pandemic related organizational changes have been assumed to decrease work-life balance.

**H5: Work – Life Balance has a direct positive impact on chemical engineers' performance.**

Bataineh (2019) explores the effect of *life-work balance* and happiness on the pharmaceutical employees' performance in Jordan and argues that enhancing life-work balance probably improve *worker's performance.* Additionally, Wolor et al. (2020) case study results the same positive effect during COVID-19 situation.

**H6: Work – Life Balance decreases Stress.**

Halkos and Bousinakis (2010) argued that *stress* among employees commonly developed due to the imbalance between the *work and the social life*, which affects the performance negatively, while suggested a weaker effect of stress on produced work quality.

**H7: Work – Life Balance increases job satisfaction.**

*Work-Life balance* has a significant positive effect on job satisfaction directly and indirectly through motivation (Alfatihah et al., 2021). Additionally, Irawanto et al. (2021) proposes the same significant positive impact of *Work-Life balance* on *job satisfaction*.

**H9: Stress have a negative impact on engineers' performance.**

Pandey (2020) discussed about how *stress* is a so common psychological factor in every person life and supported the idea of inverse relationship between stress and *performance* of workers, which means higher stress decreases the performance. And according to a study limited to female employees, Shahram et al. (2014) believed that *stresses* had a huge negative impact on their *performance*.

**H10: job satisfaction increases engineers' performance.**

Research proposed that higher employees' job satisfaction leads to higher improvement in their performance (Badrianto & Ekhsan, 2020; Mahajan & Kumar,2018; Ratna et al., 2021).

Finally, the model may contain different indirect path alternatives and mediation effects, so these paths have not been hypothesized due to prediction complexity of plentiful indirect path possibilities in the model.

# 3. METHODOLOGY

Several steps have been applied in this research as a method to investigate the COVID-19 pandemic effect on the engineers' performance as shown in figure 3.1 referring to the information cited in Dragan and Topolšek (2014), and Lai (2018). It is important to note that some of these steps are not completely discrete but rather may be overlapped (ex. reviewing the literature).

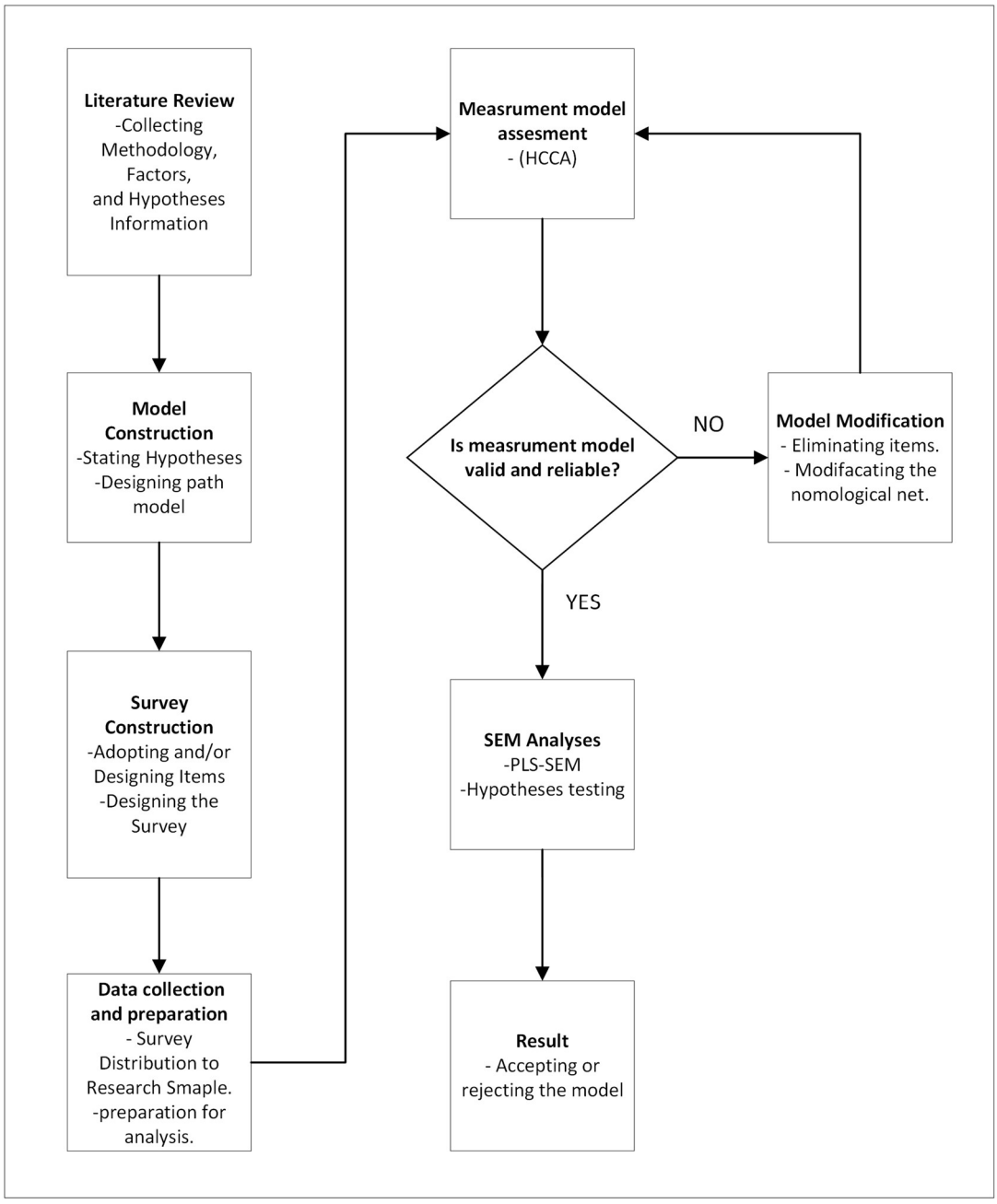


**Figure 3.1.** Flow diagram of the conducted research procedure.

### 3.1. Literature review for model construction

The methodology of this thesis starts from reviewing the literature and similar studies to understand the recent and common methodology used, which is the survey method and Structural Equation Modeling (SEM) as the mathematical analysis method (Aropah et al., 2020; Erer, 2020; Koekemoer et al., 2021; Kumar et al., 2021; Narayanamurthy and Tortorella,2021; Novitasari et.al.,2020; Quintana et al., 2021 Suratman et al., 2021; Susilo, 2020). Additionally, the factors that possibly play a role in the concerned relationship are explored and chosen through this stage, and the hypotheses suggestions which relate these factors together are considered. The generated information details of this stage are presented under the literature review section.

SEM is analytical method combines several statistical techniques to analyze causal path models that may contain complicated multilinear relationships with several dependent, independent, moderate, and mediate variables (Fan et al., 2016; Ullman & Bentler, 2012). There are two main distinct SEM methods, Covariance Based SEM (CB-SEM), and Partial Least Square SEM (PLS-SEM) where the core concept difference between them that CB-SEM estimates covariance matrices and generates other covariance matrices from the observed data, and aims to minimize the differences between these two types of matrices; while PLS-SEM aims to maximize the explained variances between factors (Hair et al., 2011; Hair et al., 2013, as cited in Hair et al. 2014). When a study develops well theoretical based structural and measurement models and aims to examine their fitness it is convenient to use CB-SEM method, while when there is no sufficient information about the constructs and the study aims to explore factors and theories the PLS-SEM method is commonly used (Hair, 2017). However, PLS-SEM can also apply to confirmative research (Hair et al., 2020). CB-SEM has more limitations than PLS-SEM makes the later more suitable for social studies (Hair, 2017). Beside the linearity assumption underlined SEM method (Ganeshkumar & Mathan Mohan, 2014), CB-SEM applies Maximum Likelihood Theory (ML) which requires multivariate normal distribution of data, data completion, relatively larger sample sizes, well-constructed models (Kaplan, 2001), and all variables considered continues (Kline 2010; Hoyle 2011, as cited in Fan et al., 2016), Li (2016) suggest the use of other two alternative estimators in case of measuring

ordinal variables and insignificant non-normality conditions, which are Robust Maximum Likelihood (MLR) and Diagonally Weighted Least Square (WLSMV). However, all CB-SEM estimators need relatively large samples, while PLS-SEM does not impose normality constraint, can proceed with relatively small sample sizes (Fan et al., 2016), and compatible with ordinal variables (Schuberth et al., 2018, as cited in Benitez et al.,2020).

Regarding sample size requirements difference, as a role of thumb PLS-SEM needs at least 10 responses per single arrow directed toward any latent factor in the model (Hair et al., 2014, as cited in Astrachan et al., 2014; Kock & Hadaya, 2018), while in CB-SEM a minimum 5 responses per measure or item are required for each investigated group (Astrachan et al., 2014).

As the model of the current research contains 10 arrows as shown in figure 1.1 and about 30 indicators, so approximated minimum 100 (10 responses times 10 arrows), or 150 (5 responses times 30 items) observation are predictably needed to use PLS-SEM or CB-SEM respectively. In addition, minimum of 100 observation per category are required as a role of thumb for multi-category analyses (Kline, 2016; Wang & Wang, 2012, as cited in Kyriazos, 2018).

Briefly, PLS-SEM is more suggested for exploratory studies, non-normal distributed data, and small sample size cases, while CB-SEM suggested for confirmatory studies, normal distributed data, and larger sample size cases. Because of the difficulty of collecting relatively large sample sizes, taking the advantage of avoiding the normality limitations, PLS-SEM seems the prober method choice for this research.

In Model Construction stage, upon results and suggestions about the factors relations from the literature the research hypotheses have been generated as stated in Chapter 2 and developed to the structural model represented in figure 1.1.

### 3.2. Survey construction

Since the survey method have been used in this study, items for each factor either have been adopted from the literature or generated during this study; in addition, items for each construct have been assessed by a panel of experts where face validity has been established. Because the chosen factors are considered latent, it is mandatory to

investigate the factors' dimensions, specify their implicated observable variables, and choose items according to their representative variables rather than selecting items randomly during survey design process. According to Ramawickrama et al. (2017) employee's performance dimensions variate significantly between different research papers and there is not a fixed theoretical framework describes the employee's performance completely, which gives the researcher the flexibility of choice between employee's performance dimensions separately or combined.

**Table 3.1** Frequency of job performance dimensions used across the literature (Ramawickrama et al., 2017)

| No | | Author/s in Chronological Order (Year)* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dimensions of Job Performance | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Total | % |
| 1 | Pro-social behaviour | × | × | | | | | | | | | | | | | 02 | 14 |
| 2 | Organization citizenship | | × | | | | | | | | × | | × | | | 03 | 21 |
| 3 | Task performance | | | × | | | × | | | | × | | × | × | × | 06 | 42 |
| 4 | Interpersonally oriented | | | × | | | | | | | | | | | | 01 | 07 |
| 5 | Downtime behaviour | | | × | | | | | | | | | | | | 01 | 07 |
| 6 | Destructive behaviour | | | × | | | | | | | | | | | | 01 | 07 |
| 7 | Job specific task behaviour | | | | × | | | | | | | | | × | | 02 | 14 |
| 8 | Non job specific behaviour | | | | × | | | | | | | | | × | | 02 | 14 |
| 9 | Written and oral communication | | | | × | | | | | | | | | × | | 02 | 14 |
| 10 | Demonstrating effort | | | | × | | | | | | | | | × | | 02 | 14 |
| 11 | Personal discipline | | | | × | | | | | | | | | × | | 02 | 14 |
| 12 | Peer and team performance | | | | × | | | | | | | | | × | | 02 | 14 |
| 13 | Supervision or leadership | | | | × | | | | | | | | | × | | 02 | 14 |
| 14 | Management/ administration | | | | × | | | | | | | | | × | | 02 | 14 |
| 15 | In role work performance | | | | | × | | | | | | | | | | 01 | 07 |
| 16 | Extra-role behaviour | | | | | × | | | | | | | | | | 01 | 07 |
| 17 | Contextual Performance | | | | | | × | × | × | | | | | × | × | 05 | 35 |
| 18 | Generic work behaviour | | | | | | | | | × | | | | | | 01 | 07 |
| 19 | Adaptive work behaviour | | | | | | | | | | | × | | × | × | 03 | 21 |
| 20 | Counterproductive behaviour | | | | | | | | | | × | | × | | × | 03 | 21 |

*(Source: based on literature)*

*1. Brief and Motowidlo, (1986), 2. Organ (1988), 3. Murphy (1989), 4. Campbell et al. (1990), 5. Borman and Brush (1993), 6. Borman and Motowidlo (1993), 7. Motowidlo and Van Scotter (1994), 8. Borman and Motowidlo (1997), 9. Hunt (1996), 10. Viswesvaran and Ones (2000), 11. Pulakos et al. (2000), 12. Rotundo and Sackett (2002), 13. Stokes (2008), 14. Koopmans et al. (2011).

In table 3.1, Ramawickrama et al. (2017) represents different dimensions of *employee's performance* used in some literature recourses between the year 1986 and 2011; additionally, it suggests four of the measures as a construct for employee's performance (EP) which are: Task performance, Contextual performance, Counterproductivity, and Adaptability. However, because of the increased number of measures and items in this research, EP has been limited to three dimensions: *Task Performance, Adaptability, and Counterproductivity.*

Campbell (1990, as cited in Koopmans, 2011) demonstrates Task performance as the individual skills in performing his/her core work assignments. Contextual performance is the individual's socio-psychological attitudes that benefit the work environment

(Borman, 1993, as cited in Koopmans, 2011), and that includes the employee's additional efforts beyond his/her normal or expected duty (Koopmans, 2011). *Counterproductivity* is any undesirable behavior that may affect the organization negatively (Spector and Fox, 2005, as cited in Ones & Dilchert, 2013). *Adaptability* or Adaptive performance is the capability of the person to adjust his/her attitudes and actions to cope with the changes. (Charbonnier-Voirin & Roussel, 2012)

Griffin, Neal, and Parker (2007, as cited by Koekemoer, 2021) describes individual's performance by three components of task performance: task proficiency which is the ability of the worker accomplish the given tasks and goals; task *adaptability* which refers to the capability of coping changes in tasks; and task initiation which means the ability of the employee to start or create the task changes. Furthermore, Narayanamurthy and Tortorella (2021) assesses the performance by two terms of task performance: *Quality* of the performed work, and *Delivery* which describes delivering the performed work in the exact required time. In this research Quality and Delivery have been represented under task performance dimension.

There is insufficiency of clear organizational change constructs through the literature (Suddaby, 2010, as cited in Suddaby & Foster, 2016), neither clearly well-defined concept, flexible assumptions, nor clearly specified causing circumstances (Suddaby & Foster, 2016) due to the fuzzy nature of organizational change a simple construct has been developed to serve the purpose of this research in the extraordinary crisis of COVID-19. Saruhan (2013) argues that organizational *changes in strategy, structure, and operations* are required to survive and compete in the continuously changing business world. *Changes in technology* are certain part of organizational change construct. (Razavi, 2013; Sara, 2011, as cited in Naveed, 2017). Wang et al. (2021) believed that Before the COVID-19 crisis most of the employees lacked the experience of *teleworking* and majority of organizations were not ready to conduct that type of work. But the crisis drove many employees toward the teleworking globally (Kniffin et al., 2020, as cited in Wang et al., 2021). Unexpectedly, *virtual working* has been the organizations' new norm because of the epidemic (Evangelakos ,2020). Due to the significancy of organizations global trend to experience the remote working facing the COVID-19 widespread, in this research the remote working has been assumed as a part of organizational changes amid the pandemic, beside the strategical, structural,

technological, and operational changes. The rest of factors items have been chosen regarding their assigned variables as shown in table 3.2

**Table 3.2** Factors and their associated variables

| Latent Factor | Related Variables |
|---|---|
| Employee performance | Task Performance –Adaptability – Counterproductivity |
| Organizational Change | Strategey – Structure – Technology – Operations – Remote Working. |
| COVID-19 Pandemic | Financial Impact – Resources Impact – Psychological Impact – Health Impact – Social life Impact. |
| Work Life Balance | Work interference with Personal/Family Life - Personal/Family Life interference with Work – Personal/Family Life improvement by Work – Work improvement by Personal/Family Life – Work and non-work activities imbalance. |
| Job Satisfaction | Enthusiasm – Salary – Promotion – Work Hours – Job Security. |
| Stress | Work Environment – Burnout – Work Stress – Job Uncertainty |

More Information of items and references are stated in table A.1 (Appendix A). All main latent factors are measured using 7-point Likert scale and assumed ordinal, as Tarka (2017) believes that Likert scale generates ordinal data or can be assumed interval in some cases. In addition, Tarka (2017) suggests 7 points Likert scale usage in SEM of latent factors as more efficient scale than other numbers of scores and stated that more than 7 point creates differentiation fuzziness to the respondents which complicates their choice-making process, while less than 7 points results in information losses due shortage in scores alternatives.

The developed survey in this stage shown in (Appendix B) and contains two main parts, demographic questions numbered from 1 to 7 ask about different aspects that may be responsible of results bias which are: *Gender, Work Experience, Marital Status, Responsibility of Child/Children, Engineering Discipline, Industry, and*

*Country*. beside the 30 survey items as the second part numbered from 8 to 37. The Control variables code information found in table A.2 (Appendix A)

### 3.3. Data collection and preparation for analysis

In this step the survey is distributed to a targeted random sample of engineers probably through online platforms and prepared for the analyses by checking for outliers and non-valid responses.

### 3.4. Measurement model assessment and modification

Conducting measurement model analysis prior to perform the SEM analysis is mandatory to ensure the validity and reliability of the measurement, there are two common methodologies of testing measurement models quality which are Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA) which is a stage of CB-SEM (Hair et al., 2014).

EFA is an adequate method when there are numerous proposed items without pre-specified theory and pre classified factors underling them, and when a research goal is reducing and classifying these items (Brown, 2014; Kline, 2014, 2015, as cited in Hair et al., 2020). Whilst CFA is more suitable for this research in comparison to EFA, since CFA applied to accept or refuse a measurement model that is founded upon pre-defined hypotheses and theory (McCoach & Newton, 2016, as cited in Mia et al., 2019). Furthermore, Hair et al. (2020) suggests a new method alternative to CFA that performed within PLS-SEM method and have advantages over CFA.

Schuberth (2020) argues that the suggested alternative method by Hair et al. (2020) must be differentiated from the original Confirmatory Composite Analysis (CCA) as Hair et al. (2020) misnamed it by CCA, so for instance this study refers to it by Hair's Confirmatory Composite Analysis (HCCA), HCCA tend to preserve more items from elimination which increases the contained information of the constructs (Hair et al., 2020), produces factor scores (Rigdon, Becker, & Sarstedt,2019, as cited in Hair et al., 2020), and can work with both formative and reflective measurement models. However, CFA has well established Goodness of Fit (GoF) indices unlike HCCA which has not, and CFA can validate independent constructs while HCCA relies on the nomological network presence to proceed (Hair et al., 2020).

HCCA methodology of Hair et al., (2020) demonstrates 7 steps for model measurement model confirmation of reflective constructs which are:

1. *Items loadings and significance estimation.* Items loading must be ≥ 0.708 at P value ≤ 0.05 (Hair et al., 2011, as cited in Hair et al., 2020), one tailed P value is preferred when the relationship sign is hypothesized (Kock, 2015).
2. *Items' reliability assessment.* squaring the loading of each items indicates item shared variance with its construct, however there is no cut off role mentioned in this regard as mentioned by Hair et al., (2020)
3. *Composite Reliability (CR) assessment.* CR measures the internal reliability of the construct and should be ≥ 0.7 (Hair et al.,2020), values above 0.95 may reflect the existence of redundant items (Hair & Risher et al., 2019, as cited in Hair et al., 2020)
4. *Convergent validity assessment.* As an indication of convergent validity, AVE should be ≥ 0.5 for each item in its construct. (Hair et al.,2020)
5. *Discriminant validity assessment.* using Heterotrait - Monotrait Ratio of Correlations (HTMT). Ranging from 0 to 1, higher HTMT value implies inadequate discriminant validity (Ab Hamid et al., 2017), 0.85 or 0.90 cutoff values are reasonable (Hair et al., 2020)
6. *Nomological validity assessment.* Assessing the effect size and significance of the paths represented in the theoretical structural model. (Hair et al., 2020)
7. *Predictive validity assessment.* there are two types of predictive validity, in-sample, and out-of-sample. In-sample predictions measure the predictive capability within the processed sample and cannot been generalized to other samples (Rigdon, 2012; Sarstedt et al., 2014, as cited in Hair et al., 2020), while out-of-sample prediction used as extrapolation power test.

Three measures should be interpreted for in-sample prediction:

(1) Coefficient of Determination ($R^2$) which varies between 0 and 1 conducting the relationship degree between dependent and independent factors (Hair et al., 2020), values of 0.25, 0.5, and 0.75 can be considered as low, medium, and large respectively. (Hair et al., 2011)

(2) Effect Size ($f^2$) illustrates the importance of independent factors by deleting them one by one and measure the $R^2$ difference (Hair et al., 2017, as cited in Hair et al.,

2020), small effect sizes range between 0.02 and 0.15, medium sizes between 0.15 and 0.35, while above 0.35 are high effects (Cohen, 1988, as cited in Hair et al., 2020).

(3) Stone-Geisser's Value ($Q^2$) which is a path model indicator that test predictive relevance (Hair et al., 2020; Ringle et al., 2015), it deletes items points in systematic manner and use undeleted points to predict the deleted ones, finally compares errors of computed means and the predicted estimates, values above zero supports the model predictive relevance (Shmueli et al., 2016). Furthermore, Hair et al., (2020) stated that any value above 0 indicates reasonable value, also values above 0.25 indicate medium predictive power, while above 0.50 is consider large predictive relevance.

PLSpredict method of SmartPLS software used for this research examines the out-of-sample prediction power by splitting the sample to number of Subgroups (K), runs iterative analysis using a Training Sample (K-1) of these groups to predict a remained holdout group in arbitrary fashion, K can be adjusted to maintain a minimum 30 holdout group size as role of thumb. $Q^2$ is also interpreted using PLSpredict algorithm ($Q^2$_predict), initially the researcher must concentrate on the research's main dependent construct, a value of $Q^2$_predict >0 means that the model results predictions better than just using the means as predictions (Hair et al., 2020). After checking $Q^2$_predict, two error indices generated by PLSpredict demonstrate the deviation between the predicted and actual scores which are Mean Absolute Error (MAE) and Root Mean Square Error (RMSE), these errors should be compared to the simple Linear Regression Model (LM) prediction errors (Hair et al., 2020). LM simply ignores the proposed structural model and predict values by establishing regressions between the endogenous and exogenous observed variables, three interpretations can be concluded upon different comparison result (Hair et al., 2020):

I. RMSE and/or MAE of PLS model > LM errors for all items; implies model predictive power deficiency.
II. RMSE and/or MAE of PLS model > LM errors for items majority; represents a weak predictive power.
III. RMSE and/or MAE of PLS model > LM errors for equal or items minority; means moderate predictive power.
IV. RMSE and/or MAE of PLS model < LM errors for all items; demonstrates high predictive power.

If the measurement model results poor measures or the survey require further improvements, adjustments can be made such as adjusting errors correlations or eliminating low loading items, also survey editing may be made in this stage (Civelek, 2018).

### 3.5. Structural Equation Modeling (SEM) analysis

After assessing the measurement model quality again on the research main sample and ensure validity and reliability, the structural model and hypotheses are examined in this stage. For PLS-SEM, the procedure can be established as following (Hair et al., 2020):

1. Multi-collinearity assessment: if there is a high correlation between independent factors or variables, most probably the significance and reliability of regression measures will be affected (Daoud, 2017). If Variance Inflated Factor (VIF) < 3; there is no multicollinearity problem (Hair et al., 2020).
2. Path model assessment: size and significance of the proposed paths should be tested, paths coefficients approach 1 or -1 conduct stronger effects, while weak effects have values closer to 0 (Hair et al., 2020)
3. Predictive validity assessment: this assessment is performed exactly as the last HCCA step which mentioned previously (ex. $R^2$, $f^2$, $Q^2$, PLSpredict) (Hair et al., 2020).

Finally, after performing both measurement model assessment and SEM, the proposed model may be accepted or rejected upon the suggested criteria in the literature.

# 4. IMPLEMENTATION AND RESULTS

## 4.1. Data and sample statistics

Firstly, the survey using Google Form has been developed to reach the respondents online during the time of COVID-19 crisis, and to ease the data collection both voluntary with snowball sampling methods have been used to reach respondents engineers mainly through engineers' groups or contacts using Facebook and LinkedIn websites. The population of working engineers have been considered globally and as rough estimate using Krejcie and Morgan (1970) suggestion, the required representative sample could be a minimum of 384 at 95% confidence level and 5% margin error. However, the number of obtained responses were far below expectation since only 100 contributions have been received in two months period (from 25/2/2022 To 26/4/2022).

After data collection the data cleaning has been performed in terms of individual's non variate responses and univariate outliers, the Standard Deviation (STD) for all items of each respondent have been calculated as displayed in table C.1 (Appendix C) to eliminate non variate responses which probably are invalid , and Box plots of each construct have been generated by SPSS software to investigate outliers as represented in figures 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6. Fortunately, neither non variate observations nor outliers have been found and the number of responses kept as one hundred.

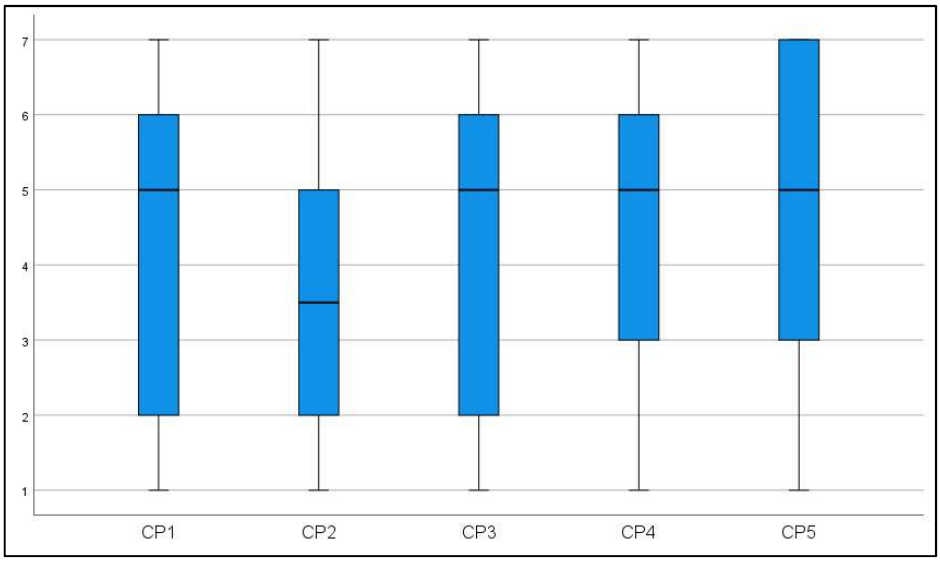


**Figure 4.1** Box plot of COVID-19 Pandemic observations.

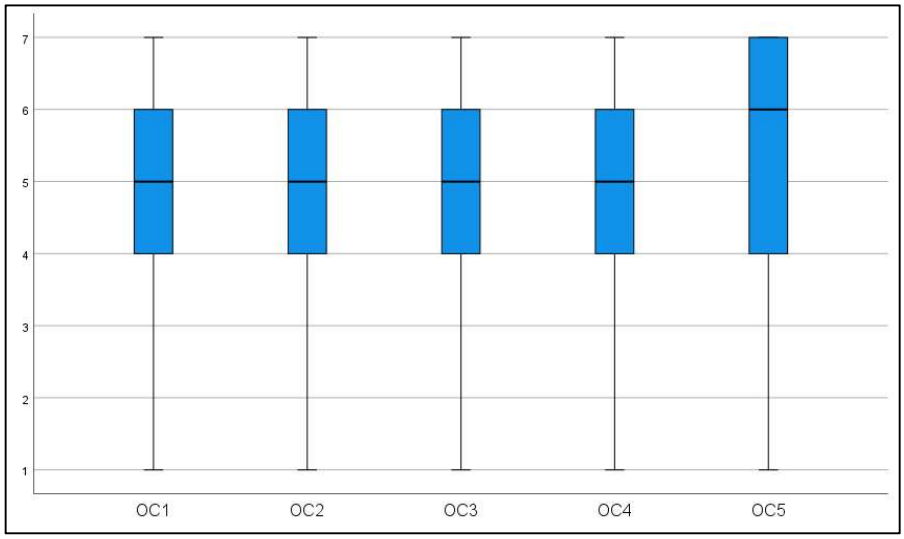


**Figure 4.2** Box plot of Organizational Change observations.

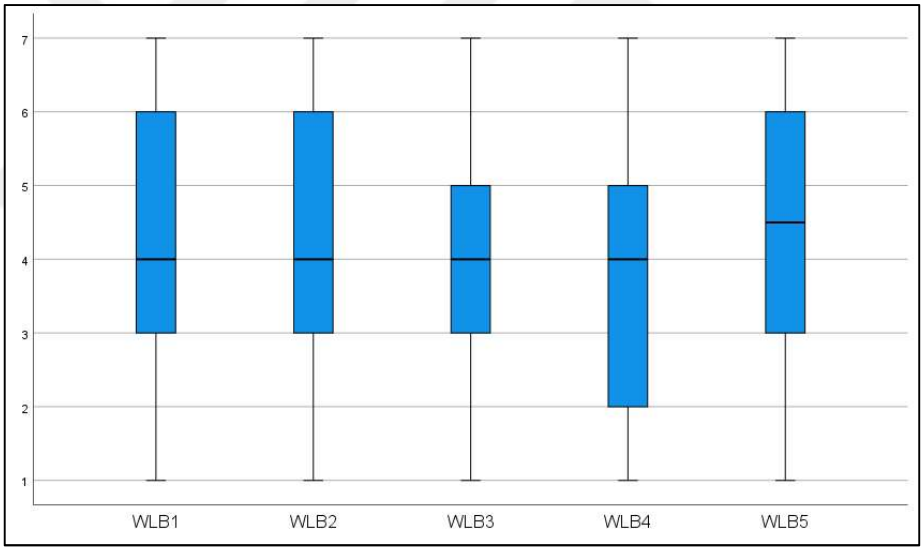


**Figure 4.3** Box plot of Work-Life Balance observations.

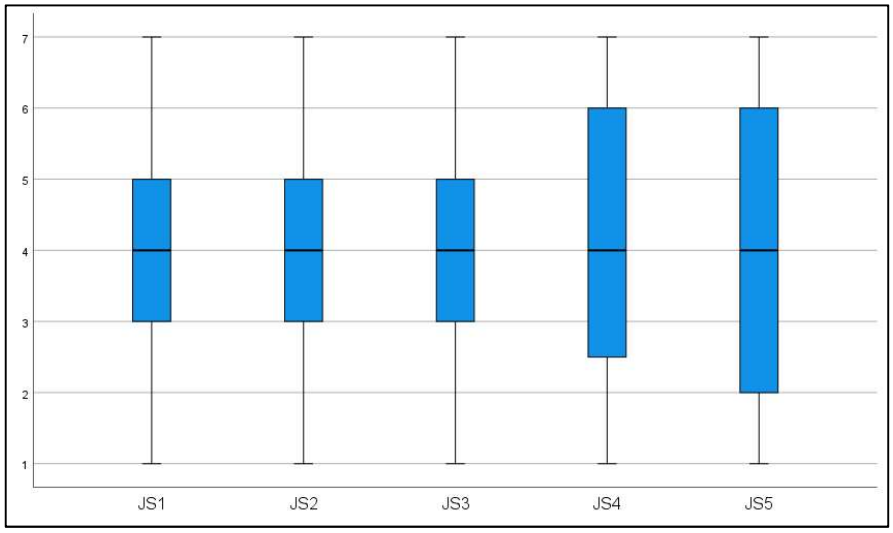


**Figure 4.4** Box plot of Job Satisfaction observations.

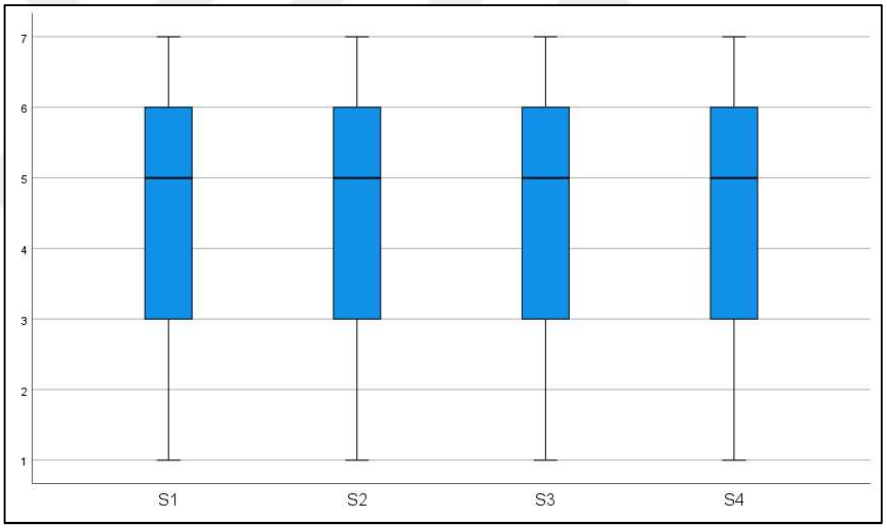


**Figure 4.5** Box plot of Stress observations.

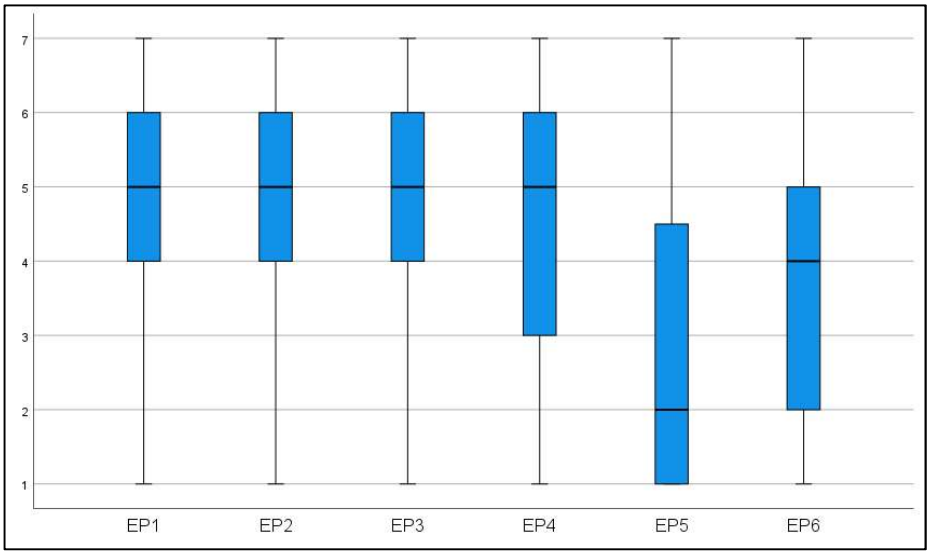


**Figure 4.6** Box plot of Engineers' Performance observations.

Some of sample demographic characteristics which are used in the SEM analysis, have been presented in table 4.1 as frequencies and further visualized in figure 4.7, number of both genders were approximately divided equally, while majority of engineers were singles, less than 5 years experienced, and have no children obligations.

**Table 4.1** Sample demographic information.

| Control Variable | Answer | Frequency |
|---|---|---|
| Gender | Male | 48 |
| | Female | 52 |
| Experience | 5 years or less | 69 |
| | 6 to 10 years | 13 |
| | 11 years or more | 18 |
| Marital Status | Single | 73 |
| | Married | 27 |
| Responsibility of children | No | 78 |
| | Yes | 22 |

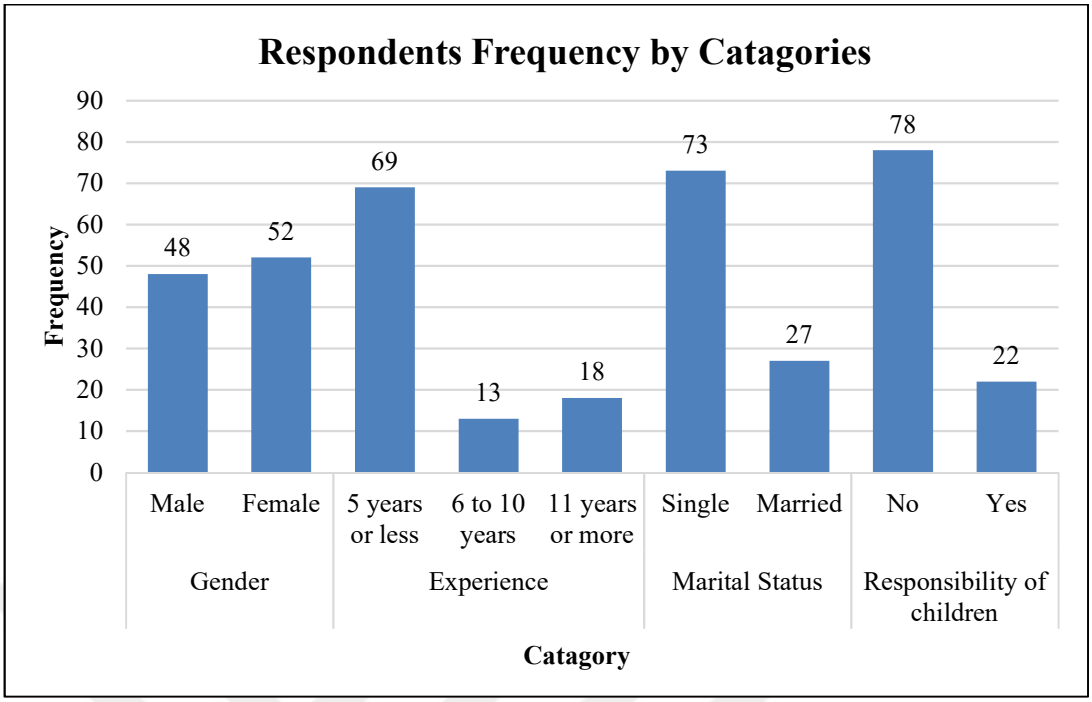


**Figure 4.7** Respondents frequency of each category.

Additionally, descriptive statistics of the computed factors mean beside control variables, and demographic information of respondents in terms of region and engineering discipline frequencies are shown in table C.2 and C.3 respectively (Appendix C), majority of respondents are from Middle East as shown in the frequencies of figure 4.8; furthermore, the engineers are closely distributed between the presented engineering disciplines which shown in figure 4.9 as calculated percentages of total 100 respondents.

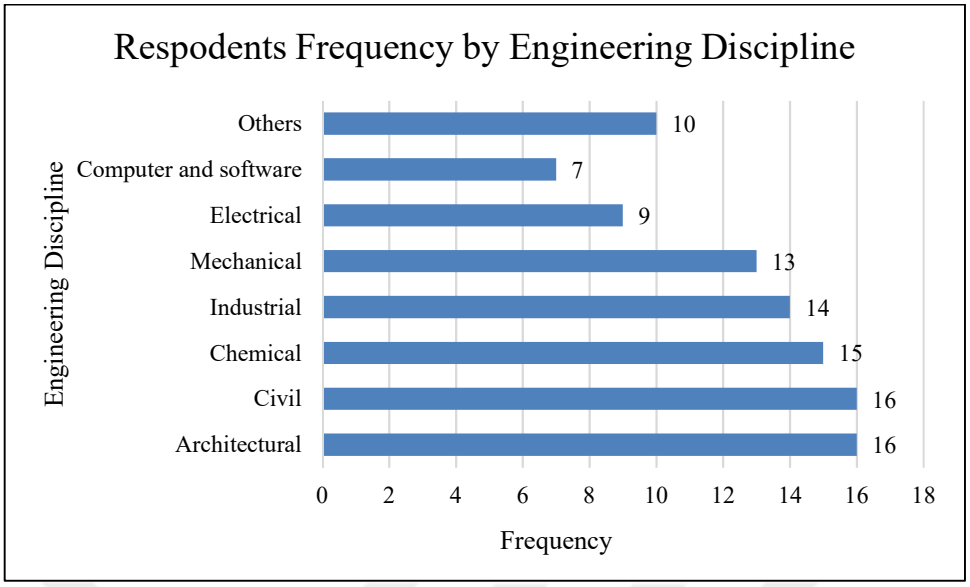


**Figure 4.8** Respondents frequency of each engineering discipline.

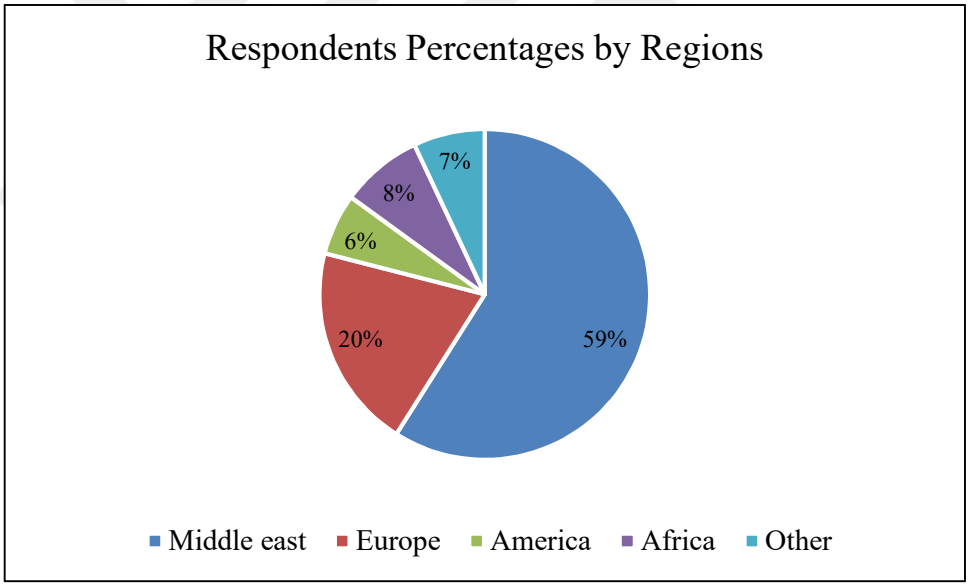


**Figure 4.9** Percentage of engineers from each region.

## 4.2. Results of the analysis

HCCA has been performed using SmartPLS software following the steps mentioned in the methodology section, settings of 10,000 iterations in each algorithm have been set with stop criterion of $10^{-7}$. At the beginning the structural and measurement models have been set completely as hypothesized in the theory before any modification as shown in figure 4.10, the circles represent factors and rectangles represent items, where items with their corresponding notation are shown in table A.1 (Appendix A).

The first step on HCCA requires items loadings assessment, to establish items' reliability each loading should be ≥ 0.708. After the first run not all the items pass the suggested loading threshold, hence the failed items have been omitted one by one and loading reassessment performed after each deletion until the passing criteria is achieved. Before and after modification are represented in table 4.2 beside the indicator reliabilities. The rejected items are: CP1, CP2, E5, E6, JS1, OC3, OC5, WLB2, WLB3, WLB4, and WLB5. All rejected items failed to achieve the recommended loading value except for item WL2 which have been omitted lastly to achieve the discriminant validity between constructs.

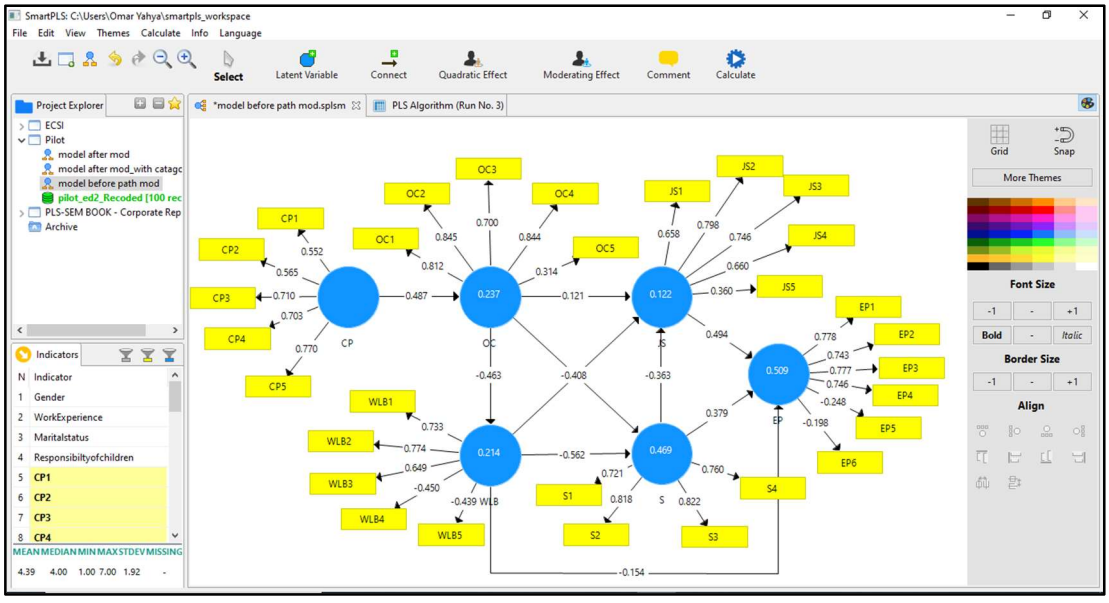


**Figure 4.10** Structural and measurement model before modification.

After reaching step 5 of HCCA and producing the HTMT values which must be < 0.90 to ensure discriminant validity (Hair et al., 2020), HTMT value of Work-Life Balance with Stress was above 0.90 as shown in the diagonal of table 4.3 which implies HTMT modification necessity. As Henseler et al., (2014) recommends deletion of the most correlated items between highly related constructs to reduce the HTMT value. In table 4.4, Item WLB2 showed the highest cross loading value on stress so it has been eliminated and HTMT values have been improved from 0.942 to 0.724, and all the constructs met the acceptance HTMT criteria of discriminant validity which is less than 0.90 as shown in the diagonal of table 4.5.

**Table 4.2** Items' loadings before and after modification

| Items | Loadings Before Modification | P Value | Loadings After Modification | Indicator Reliability |
|---|---|---|---|---|
| CP1 <- COVID-19 Pandemic | **0.552** | 0 | | |
| CP2 <- COVID-19 Pandemic | **0.565** | 0 | | |
| CP3 <- COVID-19 Pandemic | 0.710 | **0** | 0.725 | 0.526 |
| CP4 <- COVID-19 Pandemic | 0.703 | **0** | 0.802 | 0.643 |
| CP5 <- COVID-19 Pandemic | 0.770 | **0** | 0.841 | 0.707 |
| EP1 <- Engineers' Performance | 0.778 | **0** | 0.797 | 0.635 |
| EP2 <- Engineers' Performance | 0.743 | **0** | 0.778 | 0.605 |
| EP3 <- Engineers' Performance | 0.777 | **0** | 0.787 | 0.619 |
| EP4 <- Engineers' Performance | 0.746 | **0** | 0.785 | 0.616 |
| EP5 <- Engineers' Performance | **-0.248** | 0.213 | | |
| EP6 <- Engineers' Performance | **-0.198** | 0.306 | | |
| JS1 <- Job Satisfaction | **0.658** | 0 | | |
| JS2 <- Job Satisfaction | 0.798 | **0** | 0.836 | 0.699 |
| JS3 <- Job Satisfaction | 0.746 | **0** | 0.744 | 0.554 |
| JS4 <- Job Satisfaction | 0.660 | **0** | 0.768 | 0.590 |
| JS5 <- Job Satisfaction | 0.360 | 0.013 | | |
| OC1 <- Organizational Change | 0.812 | **0** | 0.84 | 0.706 |
| OC2 <- Organizational Change | 0.845 | **0** | 0.869 | 0.755 |
| OC3 <- Organizational Change | **0.700** | 0 | | |
| OC4 <- Organizational Change | 0.844 | **0** | 0.861 | 0.741 |
| OC5 <- Organizational Change | **0.314** | 0.033 | | |
| S1 <- Stress | 0.721 | **0** | 0.72 | 0.518 |
| S2 <- Stress | 0.818 | **0** | 0.822 | 0.676 |
| S3 <- Stress | 0.822 | **0** | 0.833 | 0.694 |
| S4 <- Stress | 0.760 | **0** | 0.745 | 0.555 |
| WLB1 <- Work Life Balance | 0.733 | **0** | 1 | 1.000 |
| WLB2<- Work Life Balance | **0.774** | 0 | | |
| WLB3<- Work Life Balance | **0.649** | 0 | | |
| WLB4<- Work Life Balance | **-0.450** | 0.082 | | |
| WLB5<- Work Life Balance | **-0.439** | 0.067 | | |

**Table 4.3** HTMT values before item (WLB2) elimination.

| | **CP** | **EP** | **JS** | **OC** | **S** |
|---|---|---|---|---|---|
| **EP** | 0.412 | | | | |
| **JS** | 0.142 | 0.68 | | | |
| **OC** | 0.509 | 0.546 | 0.164 | | |
| **S** | 0.685 | 0.451 | 0.237 | 0.611 | |
| **WLB** | 0.633 | 0.344 | 0.201 | 0.453 | **0.942** |

**Table 4.4** Cross loading values between Work-Life Balance and Stress constructs.

| | **S** | **WLB** |
|---|---|---|
| S1 | 0.723 | -0.596 |
| S2 | 0.829 | -0.611 |
| S3 | 0.829 | -0.551 |
| S4 | 0.74 | -0.566 |
| WLB1 | -0.638 | 0.899 |
| **WLB2** | **-0.707** | 0.919 |

**Table 4.5** HTMT values after modification.

| | **CP** | **EP** | **JS** | **OC** | **S** |
|---|---|---|---|---|---|
| **EP** | 0.412 | | | | |
| **JS** | 0.142 | 0.68 | | | |
| **OC** | 0.509 | 0.546 | 0.164 | | |
| **S** | 0.685 | 0.451 | 0.237 | 0.611 | |
| **WLB** | 0.479 | 0.229 | 0.214 | 0.346 | **0.724** |

As displayed in table 4.6, Composite reliability values are above 0.70 which supports the constructs' reliability, and all values of AVE exceed the 0.50 so the convergent validity have been achieved.

**Table 4.6** Convergent validity and construct reliability results.

| Construct | Cronbach's Alpha | Composite Reliability | AVE |
|---|---|---|---|
| CP | 0.707 | 0.833 | 0.626 |
| OC | 0.823 | 0.892 | 0.734 |
| JS | 0.695 | 0.826 | 0.614 |
| WLB | 1 | 1 | 1 |
| S | 0.786 | 0.862 | 0.611 |
| EP | 0.795 | 0.867 | 0.619 |

As an additional validity measure, Hair et al. (2020) recommends the nomological validity assessment in step 6 of HCCA, the first path estimates in table 4.7 show two insignificant paths in the hypothesized model which are the direct effect of WLB on engineers' performance and the direct effect of stress on job satisfaction. The insignificant paths have been eliminated one by one to modify the model and achieve the nomological validity, and table 4.7 represents the path estimates and significance values at each stage before and after modification of the path model, and figure 4.11 shows the model after path modification.

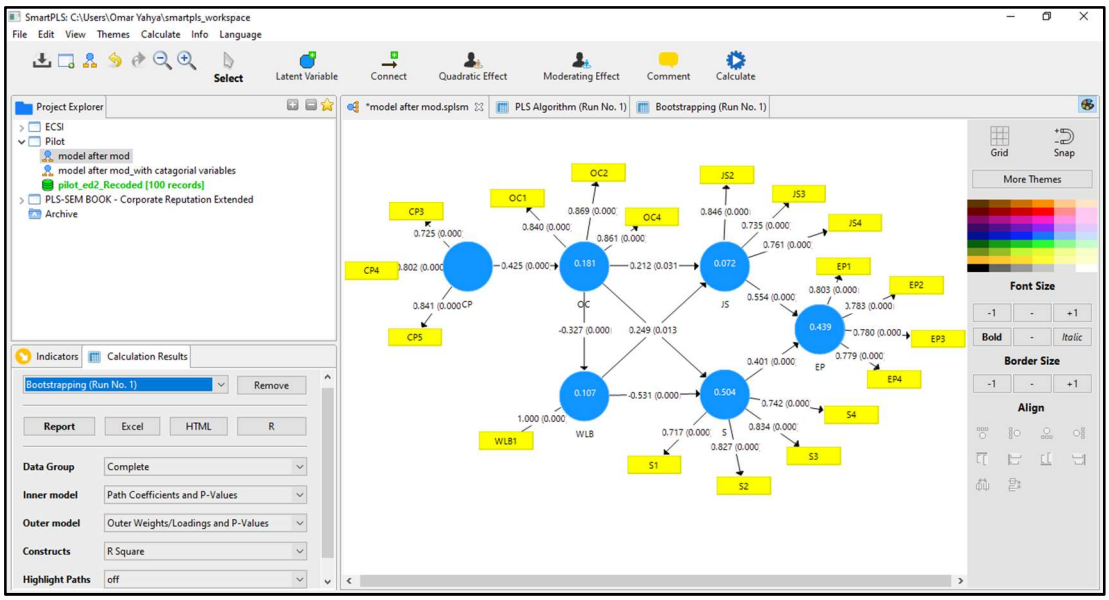


**Figure 4.11** Path model after modification.

**Table 4.7** Paths result before and after modification.

| | **Before Modification** | | **After Deleting WLB > EP** | | **After Deleting S > JS** | |
|---|---|---|---|---|---|---|
| Path | Estimate | P Values | Estimate | P Values | Estimate | P Values |
| CP -> OC | 0.426 | 0 | 0.426 | 0 | 0.425 | 0 |
| JS -> EP | 0.562 | 0 | 0.553 | 0 | 0.554 | 0 |
| OC -> JS | 0.215 | 0.033 | 0.215 | 0.032 | 0.212 | 0.031 |
| OC -> S | 0.328 | 0 | 0.328 | 0 | 0.328 | 0 |
| OC -> WLB | -0.327 | 0 | -0.327 | 0 | -0.327 | 0 |
| S -> EP | 0.351 | 0.0005 | 0.401 | 0 | 0.401 | 0 |
| S -> JS | **-0.025** | **0.4355** | **-0.025** | **0.436** | | |
| WLB -> EP | **-0.081** | **0.1705** | | | | |
| WLB -> JS | 0.234 | 0.019 | 0.234 | 0.0215 | 0.249 | 0.012 |
| WLB -> S | -0.532 | 0 | -0.532 | 0 | -0.531 | 0 |

$R^2$ results have been generated after path modification as represented in table 4.8, all the values are significant at P value<0.05 except for job satisfaction which have been considered significant at P<0.10.

Since $R^2$ values of engineers' performance and stress are around 0.50, this suggest that these two endogenous factors have been described moderately by other factors in the model. In other words, 43.9% and 50.4% of engineers' performance and stress respectively have been described by the modified model. While other factors are insufficiently described using the study sample since their $R^2$ values are below 0.25, thus adding more factors to predict JS, OC, and WLB most probably will increase the $R^2$ values since increasing exogenous factors increases the $R^2$ (Saunders et al., 2012; Zhang, 2017)

**Table 4.8** Coefficient of determination for the modified model.

| | $R^2$ | P Values |
|---|---|---|
| EP | **0.439** | 0 |
| JS | 0.072 | 0.079 |
| OC | 0.181 | 0.005 |
| S | **0.504** | 0 |
| WLB | 0.107 | 0.027 |

The effect sizes in table 4.9 suggest that almost all the proposed relationships will be significantly affected by omitting any path in the modified model, except for the paths that treat job satisfaction as endogenous factor and the effect of organizational change on WLB which represent low effect sizes (less than 0.15), these results support the suggestions of the previously interpreted $R^2$ results to add more factors that mainly explains the job satisfaction and WLB.

**Table 4.9** Effect sizes for the modified path model.

| Path | $f^2$ | P Values |
|---|---|---|
| CP -> OC | 0.221 | 0.031 |
| JS -> EP | 0.544 | 0.005 |
| OC -> JS | **0.043** | 0.218 |
| OC -> S | 0.194 | 0.062 |
| OC -> WLB | **0.120** | 0.054 |
| S -> EP | 0.286 | 0.047 |
| WLB -> JS | **0.060** | 0.169 |
| WLB -> S | 0.507 | 0.004 |

The $Q^2$ results of all endogenous factors are greater than zero as shown in table 4.10 using omission distance equal to 7 in the Blindfolding algorithm of SmartPLS software, and these results supports the predictive relevance of the model.

Since the $R^2$, $f^2$, and $Q^2$ are measures of in-sample prediction, for such a relatively so small sample size with many uncontrolled variables (ex. country, engineering discipline, industry, etc.) the results of in-sample prediction probably can be considered very reasonable, and the model most probably will improve substantially using a well-controlled and statistically powerful sample.

**Table 4.10** Stone-Geisser's values using Blindfolding algorithm.

| Factor | SSO | SSE | $Q^2$ |
|---|---|---|---|
| CP | 300 | 300 | |
| EP | 400 | 302.176 | **0.245** |
| JS | 300 | 292.414 | **0.025** |
| OC | 300 | 266.077 | **0.113** |
| S | 400 | 284.094 | **0.29** |
| WLB | 100 | 91.148 | 0.089 |

Moving to out of sample prediction results, PLSpredict algorithm of SmartPLS have been performed with K=3 subgroups and 100 repetition. Recalling Hair et al. (2020) suggestions, $Q^2$_predict for EP items represented in table 4.11 are higher than zero so the PLS model is probably indicates the main dependent factor items of the model better than using the mean values.

**Table 4.11** $Q^2$_predict results for each item using PLSpredict algorithm

| Item | PLS model | LM |
|---|---|---|
| | $Q^2$_predict | $Q^2$_predict |
| **EP1** | **0.039** | **0.063** |
| **EP2** | **0.041** | **0.057** |
| **EP3** | **0.032** | **0.033** |
| **EP4** | **0.026** | **0.015** |
| JS2 | -0.003 | -0.045 |
| JS3 | 0.005 | -0.053 |
| JS4 | -0.001 | -0.080 |
| OC1 | 0.017 | -0.006 |
| OC2 | 0.050 | 0.002 |
| OC4 | 0.207 | 0.168 |
| S1 | 0.104 | 0.138 |
| S3 | 0.113 | 0.116 |
| S4 | 0.085 | 0.054 |
| S2 | 0.102 | 0.133 |
| WLB1 | 0.092 | 0.104 |

Furthermore, subtracting the errors of LM model from the PLS model propose weak to moderate out of sample prediction power, since RMSE errors in PLS model are greater than LM errors for minority of items (6 of 15) as seen in table 4.12 so moderate out of sample prediction power may be suggested; also MEA errors of PLS model are greater than LM errors for majority of items (8 of 15) as shown in table 4.13 where weak predictive power can be interpreted.

**Table 4.12** RMSE errors difference between PLS model and LM using PLSpredict algorithm

| Item | RMSE (PLS model) | RMSE (LM) | Δ RMSE (PLS – LM) |
|---|---|---|---|
| EP1 | 1.75 | 1.728 | **0.022** |
| EP2 | 1.763 | 1.748 | **0.015** |
| EP3 | 1.383 | 1.383 | 0.000 |
| EP4 | 1.635 | 1.645 | -0.010 |
| JS2 | 1.779 | 1.815 | -0.036 |
| JS3 | 1.839 | 1.892 | -0.053 |
| JS4 | 1.874 | 1.946 | -0.072 |
| OC1 | 1.795 | 1.816 | -0.021 |
| OC2 | 1.64 | 1.682 | -0.042 |
| OC4 | 1.485 | 1.521 | -0.036 |
| S1 | 1.682 | 1.649 | **0.033** |
| S3 | 1.717 | 1.714 | **0.003** |
| S4 | 1.851 | 1.882 | -0.031 |
| S2 | 1.702 | 1.673 | **0.029** |
| WLB1 | 1.875 | 1.863 | **0.012** |

**Table 4.13** MAE errors difference between PLS model and LM using PLSpredict algorithm

| Item | MAE (PLS model) | MAE (LM) | Δ MAE (PLS – LM) |
|---|---|---|---|
| EP1 | 1.412 | 1.343 | **0.069** |
| EP2 | 1.413 | 1.411 | **0.002** |
| EP3 | 1.102 | 1.122 | -0.020 |
| EP4 | 1.339 | 1.320 | **0.019** |
| JS2 | 1.46 | 1.501 | -0.041 |
| JS3 | 1.508 | 1.517 | -0.009 |
| JS4 | 1.592 | 1.653 | -0.061 |
| OC1 | 1.459 | 1.477 | -0.018 |
| OC2 | 1.354 | 1.391 | -0.037 |
| OC4 | 1.234 | 1.244 | -0.010 |
| S1 | 1.39 | 1.271 | **0.119** |
| S3 | 1.413 | 1.408 | **0.005** |
| S4 | 1.557 | 1.539 | **0.018** |
| S2 | 1.446 | 1.422 | **0.024** |
| WLB1 | 1.566 | 1.510 | **0.056** |

In this stage after conducting all HCCA steps, most probably the measurement model results show acceptable reliability and validity despite the probable weaknesses of the used sample.

Two steps remain to conduct structural model assessment which are multicollinearity assessment by testing VIF values, then path and hypotheses assessment. As seen in figure 4.12, beside the modified model some of control variables have been added for further examination, these variables are *Gender, Work Experience, Responsibility of children, and Marital status.* following the implementation of Ziaul & Tehjeeb (2020) which suggest regressing the control variables on the main dependent factor of the study and perhaps on other factors that probably suspected to be influenced by control variables; all control variables have been regressed on EP factor, and both responsibility of children with marital status have been regressed on WLB.

Firstly, all VIF values shown in table 4.14 are less than 3 which refute the existence of multicollinearity problem between the constructs.

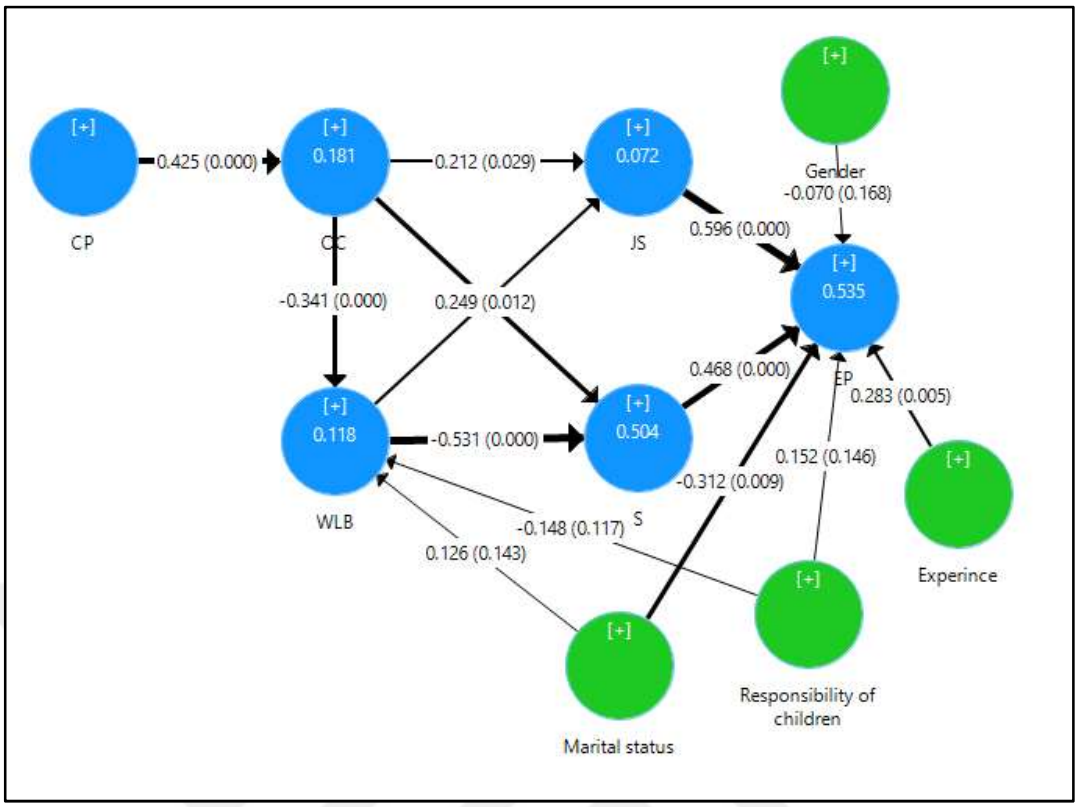


**Figure 4.12** Modified structural model with categorical variables.

**Table 4.14** VIF results of the structural model.

| | CP | EP | JS | OC | S | WLB |
|---|---|---|---|---|---|---|
| CP | | | | 1 | | |
| EP | | | | | | |
| JS | | 1.004 | | | | |
| OC | | | 1.12 | | 1.12 | 1 |
| S | | 1.004 | | | | |
| WLB | | | 1.12 | | 1.12 | |

Table 4.15 represents each hypothesis with its corresponding path estimates for testing, path effects of gender on engineers' performance, marital status on work-life balance, and responsibility of children on both engineers' performance and work-life balance are insignificant, since marital status as a dump variable shows negative estimate value on performance and single status is coded zero, this indicates that single engineers probably perform higher than married engineers. While ordinal experience variable

has positive path effect which suggest relatively increased performance for more experienced engineers.

Regarding hypotheses testing, H5 and H8 have been eliminated during HCCA to achieve the recommended nomological validity, so the direct effect of WLB on EP and the direct effect of stress on JS cannot be justified the collected sample results.

The paths of H2 and H9 show opposite effect of what have been expected, H2 hypothesized the negative effect of organizational changes on job satisfaction but the result suggests a relatively weak positive impact. However, as Hayajneh et al. (2021) results also suggest the positive impact of OC on the employees' job satisfaction, the supportive culture of organizations may overcome the negative consequences of organizational change and result a positive impact on job satisfaction (Crown & Ivany, 2017, as cited in Malatjie, 2019), and probably there are other factors mediate and cause the positive impact of OC and JS path.

In addition, stress was expected to affect EP negatively in H9 but it instead enhanced it, this results agrees with the idea that the proper amount of stress could motivate and push employees to accomplish their work adequately which increase their performance (Chen & Fang, 2019; Jarinto, 2010), so most probably the majority of the examined sample have experienced well managed conditions in their organizations during the pandemic which enabled raising just the proper amount of motivational stress to improve the performance.

H1, H3, H4, H6, H7, and H10 are supported by path results; H1 path suggests that COVID-19 pandemic increased the organizational changes moderately by factor of 0.425 which seems very reasonable since the pandemic and the major difficult situations in general most probably require adaptation and survival actions taken by organizations. Furthermore, organizational changes increased stress slightly as H3 result conducts, but probably that stress was well handled by the organizations along with their engineers since it improved the performance rather than harming it, although

H4 path suggests that OC decreased work-life balance slightly, but it seems it did not reach the harmful level since engineers still satisfied slightly by their WLB as hinted by H7. Additionally, what may suggest the previous prediction is that despite the slightly decreased level of WLB it was enough not only to satisfy engineers but also decrease their stress moderately as shown in H6. The result of H10 path suggest that

job satisfaction increased the EP considerably, so most of examined engineers were managed to be satisfied after all.

**Table 4.15** Direct path estimates and significance.

| Hypothesis | sign | Path | Path estimates | P Values |
|---|---|---|---|---|
| H1 | + | CP -> OC | +0.425 | 0 |
| | | Experience -> EP | +0.283 | 0.005 |
| | | Gender -> EP | -0.070 | **0.163** |
| H10 | + | JS -> EP | +0.596 | 0 |
| | | Marital status -> EP | -0.312 | 0.009 |
| | | Marital status -> WLB | +0.126 | **0.138** |
| **H2** | **-** | **OC -> JS** | **+0.212** | 0.028 |
| H3 | + | OC -> S | +0.328 | 0 |
| H4 | - | OC -> WLB | -0.341 | 0 |
| | | Responsibility of child -> EP | +0.152 | **0.144** |
| | | Responsibility of child -> WLB | -0.148 | **0.114** |
| **H9** | **-** | **S -> EP** | **+0.468** | 0 |
| H7 | + | WLB -> JS | +0.249 | 0.013 |
| H6 | - | WLB -> S | -0.531 | 0 |

To overview the path results, total path effects is represented in table 4.14, which sums all the pathways alternatives between two latent factors, the most important interpretation that can be concluded that the total effect of COVID-19 pandemic on Engineer's performance is a weak positive effect (+ 0.116, table 4.16) according to the investigated sample, and that occurred because COVID-19 moderately increased organizational change implementations (+0.425, table 4.15), and probably the implementation of these organizational changes were successful thus the total effect result of organizational change on engineers' performance suggests a net positive impact (+0.274, table 4.16). Multi-group analyses have not been performed due to lack of sufficient sample size, since each group requires a minimum of 100 observation to conduct the analyses. (Kline, 2016; Wang & Wang, 2012, as cited in Kyriazos, 2018).

Since all steps of PLS-SEM and HCCA have been conducted, and the results have been within the acceptable thresholds, both measurement and structural model can be considered acceptable with indicated overall good predictive power.

**Table 4.16** Total effects of the path model.

| Total Path | Total Effect | P Value |
|---|---|---|
| CP -> EP | **0.116** | 0.016 |
| CP -> JS | 0.056 | 0.172 |
| CP -> OC | 0.425 | 0 |
| CP -> S | 0.214 | 0 |
| CP -> WLB | -0.139 | 0.004 |
| JS -> EP | 0.554 | 0 |
| OC -> EP | **0.274** | 0.002 |
| OC -> JS | 0.13 | 0.146 |
| OC -> S | 0.502 | 0 |
| OC -> WLB | -0.327 | 0 |
| S -> EP | 0.401 | 0 |
| WLB -> EP | -0.075 | 0.202 |
| WLB -> JS | 0.249 | 0.012 |
| WLB -> S | -0.531 | 0 |

# 5. CONCLUSION

The sudden development of COVID-19 pandemic evoked the need of employees' performance assessment to investigate the effect of this crisis on it. Mostly at this instant, there is no focus on the engineers' performance in the literature although the critical role which engineers most probably play in any organization. This droves the research to explore the impact of COVID-19 pandemic on the engineers' performance specifically and develop a valid and reliable model that indicates this relationship. Newly proposed method of Hair et al. (2020), is used to confirm the constructed measurement model quality in terms of reliability and validity within the PLS-SEM method, which after modification showed reliable and valid model with predictive features.

Hypothesized direct effects of "*work life balance on employee performance*" and "*stress on job satisfaction*" (H5 & H8 respectively) have been eliminated during model modification step, while "*organizational change effect on job satisfaction*" and "*stress effect on engineers' performance*" (H2 & H9 respectively) have shown opposite sign of what expected. The rest of the hypotheses were supported by the path results, and the net effect of total paths suggested *a weak positive impact of COVID-19 epidemic on engineers' performance* (0.116, Table 4.16).

The main limitation of the study is the sample size and the generalizability of the results, since collecting a large and well representative data of a global population of engineers were quite difficult to achieve. Thus, conducting further research using this constructed model on more representative sample can be suggested during similar situation of this pandemic. Furthermore, since the variance of job satisfaction, WLB, and OC have not been explained sufficiently by the represented factors in the model according to the small $R^2$ and $f^2$ values (Tables 4.8 & 4.9), it is highly recommended to add exogenous factors that probably impact job satisfaction and WLB directly to improve the model as organizational culture and management related factors, also hypothesizing more direct effects on organizational change most probably will be an excellent plus.

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# APPENDIX A

**Table A.1** Survey items information before factor analyses

| # item | Survey Items | | | |
|---|---|---|---|---|
| | COVID-19 Pandemic | | | |
| | Original Items | Variable | Modified/used Items | Refrences |
| CP1 | The Coronavirus (COVID-19) pandemic has impacted me negatively from financial point of view. | Financial Impact | The Coronavirus (COVID-19) pandemic has impacted me negatively from financial point of view. | Conway, Woodard & Zubrod (2020) |
| CP2 | I have had a hard time getting needed resources (food, toilet paper) due to the Coronavirus (COVID-19). | Resources Impact | I have experienced hard time getting needed resources (food, toilet paper, masks, etc..) due to (COVID-19) pandemic. | |
| CP3 | I have become depressed because of the Coronavirus (COVID-19). | Psychological Impact | I have become depressed, anxious, and/or stressed because of the (COVID-19) pandemic. | |
| CP4 | I beleive that (COVID-19) is a major threat to the general health. | Health Impact | I believe (COVID-19) has threatened my general health. | Van Rooij et al. (2020) |
| CP5 | On a scale of 1 to 5, how do you think the lockdown has affected your social life? | Social life Impact | I think (COVID-19) pandemic consequences (lockdown, social distance, etc..) have affected my social life negatively. | Adenubi et al. (2021) |
| | Organizational Change | | | |
| | Original Items | Notation | Modified Items | Refrences |
| OC1 | | structural change | During COVID-19 pandemic, structural change has been implemented by my unit/organization | Developed for this research. |
| OC2 | | strategical change | During COVID-19 pandemic, strategical change has been implemented by my unit/organization. | |
| OC3 | | technological change | During COVID-19 pandemic, technological change has been implemented by my unit/organization. | |

| | | | | |
|---|---|---|---|---|
| OC4 | | operational change | During COVID-19 pandemic, operational change has been implemented by my unit/organization. | |
| OC5 | | Teleworking application | During COVID-19 pandemic, remote working method has been applied in my unit/organization. | |
| | Work-life balance | | | |
| | Original Items | Notation | Modified Items | Refrences |
| WLB1 | I have difficulty balancing my work and non-work activities.* | Work and non-work activities imbalance | During COVID-19 pandemic, I have difficulty in balancing my work and non-work activities. | Brough et al. (2014) |
| WLB2 | The tiresome demands of work do not allow me to lead to personal life that I like.* | Work interference with Personal/ Family Life | During COVID-19 pandemic, tiresome work does not allow me to lead the personal life that I like | Rincy & Panchanatham(2010) |
| WLB3 | The stress originating from my personal/family life make me unable to concentrate on my work* | Personal/ Family Life interference with Work | During COVID-19 pandemic, stress originating from my personal/family life has made me unable to concentrate on my work | |
| WLB4 | My work schedule helps me to plan and execute my family activities regularly | Personal/ Family Life improvement by Work | During COVID-19 pandemic, my work schedule has helped me to plan and execute my personal/family activities regularly | |
| WLB5 | My family life gives me energy and better mood to perform my duties at work places | Work improvement by Personal/ Family Life | During COVID-19 pandemic, my personal/family life have given me energy and better mood to perform my duties at workplace | |
| | Job Satisfaction | | | |
| | Original Items | Notation | Modified Items | Refrences |
| JS1 | Most days I am enthusiastic about my work | Enthusiasm | During COVID-19 pandemic, most days I have been enthusiastic about my work | Sinval & Marôco (2020) |
| JS2 | I feel I am being paid a fair amount for the work I do. | Salary | During COVID-19 pandemic, I feel I have been paid a fair amount for the work I do. | Parlalis (2011) |

| | | | | |
|---|---|---|---|---|
| JS3 | those who do well on the job stand a fair chance of being promoted. | Promotion | During COVID-19 pandemic, those who do well on the job have fair chance of being promoted. | |
| JS4 | I am satisfied with my working hours | working hours | During COVID-19 pandemic, I have been satisfied with my working hours | Gupta et al. (2018) |
| JS5 | I have no fear of losing my job because of technology | Job Security | During COVID-19 pandemic, I have no fear of losing my job | Anyaoku et al. (2015) |
| | Stress | | | |
| | Original Items | Notation | Modified Items | Refrences |
| S1 | My working environment is very stressful. | Work Environment | During COVID-19 pandemic, my working environment has been very stressful. | Bernas & Major (2000) |
| S2 | I have too much work to do. | Work Stress | During COVID-19 pandemic, I feel like I have too much work to do. | |
| S3 | I feel "burned-out" after a full day of work | Burnout | During COVID-19 pandemic, I have felt "burned-out" after a full day of work | |
| S4 | I am uncertain about my future with this organization. | Job Uncertainty | During COVID-19 pandemic, I feel uncertain about my future with this organization. | O'Neill (2011) |
| | Employee Performance | | | |
| | Original Items | Notation | Modified Items | Refrences |
| EP1 | I managed to plan my work so that i finished it on time | Time | During COVID-19 pandemic, I have managed to plan my work so that I finished it on time. | Ramos-Villagrasa et al. (2019) |
| EP2 | I am pretty sure of complying with the standards of quality. | Quality | During COVID-19 pandemic, I have managed to comply with the standards of quality. | KESKİN (2020) |
| EP3 | I use to cope well with organizational changes from time to time. | Adabtability | During COVID-19 pandemic, I have used to cope well with organizational changes. | (Pradhan & Jena, 2016) |
| EP4 | I was able to cope well with uncertain and unpredictable situations at work | Adabtability | During COVID-19 pandemic, I have been able to cope well with difficult and unpredictable situations at work | (Koopmans et al., 2012) |
| EP5 | I purposely left my work so that someone else had to finish it | Counterproductivity | During COVID-19 pandemic, I have left my work purposely, | |

| | | | | |
|---|---|---|---|---|
| | | | so that someone else had to finish it. | |
| EP6 | I focused on the negative aspects of a work situation, instead of on the positive aspects. | Counterproductivity | During COVID-19 pandemic, I have focused on the negative aspects of a work situation, instead of positive aspects. | Koopmans et al. (2013) |

**Table A.2** Control variables with their codes

| Variable | Scale Type | Code |
|---|---|---|
| Gender | Nominal | 0= Male; 1= Female |
| Responsibilty of Child/Children | Nominal | 0=No; 1=Yes |
| Marital Status | Nominal | 0=Single; 1=Married |
| Work Experience | Ordinal | 1= 5 years or less;<br>2= 6 to 10 years<br>3= 11 years or more |
| Engineering Discipline | Nominal | |
| Industry | | |
| Country | | |

# APPENDIX B

This survey is part of an Engineering Management Master thesis at Istanbul Kultur University (IKU), with the aim of analyzing "*The Impact of COVID-19 Pandemic on the Engineers' Performance"*. Your contribution is very valuable and well appreciated.

**Note:** This survey is for scientific research purposes, and all the respondents will stay anonymous, please feel free to answer according to your true feelings and experience. The survey contains 2 sections with total of 37 questions and takes around 10 minutes to complete.

1-Please answer the following questions about your demographic information:

1- What is your gender? ( ) Male; ( ) Female
2- How long is your work Experience?
( ) 5 years or less; ( ) 6 to 10 years; ( ) 11 years or more
3- What is your marital status? Married ( ); Single ( )
4- Do you have a child / children? ( )Yes; ( )No
5- What is your engineering discipline?
( ) Industrial; ( ) Chemical; ( ) Mechanical; ( ) Civil
( ) Electrical; ( ) Agricultural; ( ) Biomedical; ( )Architectural; ( ) Other
6- Which industry do you work in during the pandemic? (ex: Food industry, Pharmaceutical industry, Automotive Industry, etc..)
.....
7- Which Country do you work in during the pandemic?
.....

2- Considering your experience during COVID-19 pandemic, please mark your agreement level on the following statements according to the scale bellow from 1 to 7

| **Scale:** (1) Strongly Disagree; (2) Disagree; (3) Slightly Disagree; (4) Neither Disagree nor Agree; (5) Slightly Agree; (6) Agree; (7) Strongly Agree | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Scores:** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| 8 | The Coronavirus (COVID-19) pandemic has impacted me negatively from financial point of view. | | | | | | | |
| 9 | I have experienced hard time getting needed resources (food, toilet paper, masks, etc..) due to (COVID-19) pandemic. | | | | | | | |
| 10 | I have become depressed, anxious, and/or stressed because of the (COVID-19) pandemic. | | | | | | | |
| 11 | I believe (COVID-19) has threatened my general health. | | | | | | | |
| 12 | I think (COVID-19) pandemic consequences (lockdown, social distance, etc..) have affected my social life negatively. | | | | | | | |
| 13 | During COVID-19 pandemic, structural change has been implemented by my unit/organization. | | | | | | | |
| 14 | During COVID-19 pandemic, strategical change has been implemented by my unit/organization. | | | | | | | |
| 15 | During COVID-19 pandemic, technological change has been implemented by my unit/organization. | | | | | | | |
| 16 | During COVID-19 pandemic, operational change has been implemented by my unit/organization. | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 17 | During COVID-19 pandemic, remote working method has been applied in my unit/organization. | | | | | | | |
| 18 | During COVID-19 pandemic, I have difficulty in balancing my work and non-work activities. | | | | | | | |
| 19 | During COVID-19 pandemic, tiresome work has not allowed me to lead the personal life that I like | | | | | | | |
| 20 | During COVID-19 pandemic, stress originating from my personal/family life has made me unable to concentrate on my work. | | | | | | | |
| 21 | During COVID-19 pandemic, my work schedule has helped me to plan and execute my personal/family activities regularly. | | | | | | | |
| 22 | During COVID-19 pandemic, my personal/family life have given me energy and better mood to perform my duties at workplace. | | | | | | | |
| 23 | During COVID-19 pandemic, most days I have been enthusiastic about my work. | | | | | | | |
| 24 | During COVID-19 pandemic, I have been paid a fair amount for the work I do. | | | | | | | |
| 25 | During COVID-19 pandemic, those who do well on the job have fair chance of being promoted. | | | | | | | |
| 26 | During COVID-19 pandemic, I have been satisfied with my working hours. | | | | | | | |
| 27 | During COVID-19 pandemic, I have no fear of losing my job | | | | | | | |
| 28 | During COVID-19 pandemic, my working environment has been very stressful. | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 29 | During COVID-19 pandemic, I have felt like I have too much work to do. | | | | | | | |
| 30 | During COVID-19 pandemic, I have felt “burned-out” after a full day of work. | | | | | | | |
| 31 | During COVID-19 pandemic, I have felt uncertain about my future with this organization. | | | | | | | |
| 32 | During COVID-19 pandemic, I have managed to plan my work so that I finished it on time. | | | | | | | |
| 33 | During COVID-19 pandemic, I have managed to comply with the standards of quality. | | | | | | | |
| 34 | During COVID-19 pandemic, I have used to cope well with organizational changes. | | | | | | | |
| 35 | During COVID-19 pandemic, I have been able to cope well with difficult and unpredictable situations at work. | | | | | | | |
| 36 | During COVID-19 pandemic, I have left my work purposely so that someone else had to finish it. | | | | | | | |
| 37 | During COVID-19 pandemic, I have focused on the negative aspects of a work situation, instead of positive aspects. | | | | | | | |

# APPENDIX C

**Table C.1** Standard error of each respondent.

| Responses | STD |
|---|---|
| 1 | 2.062528 |
| 2 | 1.393334 |
| 3 | 1.79046 |
| 4 | 1.855715 |
| 5 | 1.978331 |
| 6 | 1.578956 |
| 7 | 1.041661 |
| 8 | 1.325697 |
| 9 | 2.186689 |
| 10 | 1.801978 |
| 11 | 0.899553 |
| 12 | 1.540264 |
| 13 | 2.19325 |
| 14 | 1.888866 |
| 15 | 1.753814 |
| 16 | 1.464131 |
| 17 | 2.160513 |
| 18 | 1.487496 |
| 19 | 1.855715 |
| 20 | 1.47157 |
| 21 | 0.791478 |
| 22 | 1.942862 |
| 23 | 1.591645 |
| 24 | 1.195778 |
| 25 | 2.8333 |
| 26 | 1.063501 |
| 27 | 1.43839 |
| 28 | 1.691425 |
| 29 | 2.157318 |
| 30 | 1.323527 |
| 31 | 1.779836 |
| 32 | 1.569831 |
| 33 | 2.148509 |
| 34 | 1.83234 |
| 35 | 1.184187 |
| 36 | 1.888866 |
| 37 | 1.49674 |
| 38 | 2.61758 |
| 39 | 1.547709 |
| 40 | 1.098065 |
| 41 | 0.626062 |
| 42 | 1.547709 |
| 43 | 1.245221 |
| 44 | 2.045741 |
| 45 | 1.47157 |

| | |
|---|---|
| 46 | 1.562491 |
| 47 | 1.928611 |
| 48 | 2.122945 |
| 49 | 0.660895 |
| 50 | 1.876963 |
| 51 | 1.622046 |
| 52 | 2.186689 |
| 53 | 1.97804 |
| 54 | 1.33735 |
| 55 | 1.654322 |
| 56 | 1.014833 |
| 57 | 0.718395 |
| 58 | 1.098065 |
| 59 | 2.266447 |
| 60 | 0.731083 |
| 61 | 1.607811 |
| 62 | 1.756433 |
| 63 | 1.546594 |
| 64 | 1.082781 |
| 65 | 2.778406 |
| 66 | 1.874205 |
| 67 | 1.8585 |
| 68 | 2.049951 |
| 69 | 2.64814 |
| 70 | 1.940494 |
| 71 | 1.931291 |
| 72 | 0.718395 |
| 73 | 1.994533 |
| 74 | 1.604949 |
| 75 | 1.49674 |
| 76 | 0.844182 |
| 77 | 2.150915 |
| 78 | 0.547723 |
| 79 | 0.927857 |
| 80 | 1.887953 |
| 81 | 1.061879 |
| 82 | 1.212957 |
| 83 | 1.142693 |
| 84 | 1.404426 |
| 85 | 1.729062 |
| 86 | 1.284747 |
| 87 | 1.008014 |
| 88 | 1.701926 |
| 89 | 1.72873 |
| 90 | 1.351457 |
| 91 | 1.856953 |
| 92 | 1.904622 |
| 93 | 1.936046 |
| 94 | 2.486978 |
| 95 | 1.67332 |
| 96 | 2.192201 |

| | |
|---|---|
| 97 | 1.591645 |
| 98 | 1.606023 |
| 99 | 1.397864 |
| 100 | 2.242741 |

**Table C.2** Descriptive Statistics of control variables and latent factor means

| | N | Mean | Std. Deviation | Skewness | | Kurtosis | |
|---|---|---|---|---|---|---|---|
| | | | | Statistic | Std | Statistic | Std |
| Gender | 100 | 0.520 | 0.502 | -0.081 | 0.241 | -2.034 | 0.478 |
| Work Experience | 100 | 1.490 | 0.785 | 1.185 | 0.241 | -0.310 | 0.478 |
| Marital Status | 100 | 0.270 | 0.446 | 1.052 | 0.241 | -0.912 | 0.478 |
| Responsibilty of children | 100 | 0.220 | 0.416 | 1.373 | 0.241 | -0.119 | 0.478 |
| CP | 100 | 4.298 | 1.300 | -0.550 | 0.241 | -0.247 | 0.478 |
| OC | 100 | 4.810 | 1.250 | -0.682 | 0.241 | 0.520 | 0.478 |
| WLB | 100 | 3.958 | 0.975 | -0.050 | 0.241 | 0.613 | 0.478 |
| JS | 100 | 3.970 | 1.184 | -0.220 | 0.241 | -0.091 | 0.478 |
| S | 100 | 4.488 | 1.420 | -0.543 | 0.241 | -0.048 | 0.478 |
| EP | 100 | 4.635 | 1.029 | -0.229 | 0.241 | 0.253 | 0.478 |

**Table C.3** Respondents' regions and engineering disciplines.

| **Region** | **Frequency** | **Percentage** | **Engineering Discipline** | **Frequency** | **Percentage** |
|---|---|---|---|---|---|
| middle east | 59 | 59% | Architectural | 16 | 16% |
| Europe | 20 | 20% | Civil | 16 | 16% |
| America | 6 | 6% | Chemical | 15 | 15% |
| Africa | 8 | 8% | Industrial | 14 | 14% |
| Other | 7 | 7% | Mechanical | 13 | 13% |
| **Country** | **Frequency** | **Percentage** | Electrical | 9 | 9% |
| Turkey | 17 | 17% | Computer and software | 7 | 7% |
| Jordan | 28 | 28% | Others | 10 | 10% |