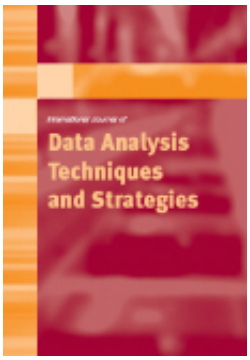


International Journal of Data Analysis Techniques and Strategies

ISSN online: 1755-8069 - ISSN print: 1755-8050
https://www.inderscience.com/ijdats

Modelling the critical success factors of software development freelancing using an intuitionistic fuzzy DEMATEL approach

Dharyll Prince Mariscal Abellana

DOI: 10.1504/IJDATS.2024.10062092

Article History:

Received:	23 April 2023
Last revised:	24 April 2023
Accepted:	22 November 2023
Published online:	19 March 2024

Modelling the critical success factors of software development freelancing using an intuitionistic fuzzy DEMATEL approach

Dharyll Prince Mariscal Abellana

Department of Computer Science,
University of the Philippines Cebu,
Cebu City, 6000 Cebu, Philippines
Email: dmabellana@up.edu.ph

Abstract: This paper investigates the critical success factors of software development freelancing in the Philippines during the COVID-19 pandemic. The paper adopts the intuitionistic fuzzy decision making trial and evaluation laboratory (IF-DEMATEL), which is a causal modelling approach based on multiple criteria decision making and intuitionistic fuzzy set theory. As a result, the study was able to derive 26 critical success factors for software development freelancing. The study finds significant cause groups and effect groups among the critical success factors. In particular, results suggest that the cause groups are highly associated with the management-side of the project than any other factor. The results of this study would be significant to the literature in many ways. For one, it is the first to investigate the critical success factors of software development freelancing. For another, it is the first to model the dynamics of these critical success factors under a causal modelling framework.

Keywords: intuitionistic fuzzy sets; freelancing during the COVID-19 pandemic; critical success factors; software development; soft computing.

Reference to this paper should be made as follows: Abellana, D.P.M. (2024) 'Modelling the critical success factors of software development freelancing using an intuitionistic fuzzy DEMATEL approach', *Int. J. Data Analysis Techniques and Strategies*, Vol. 16, No. 1, pp.17–31.

Biographical notes: Dharyll Prince Mariscal Abellana is the Chairperson of the Department of Computer Science at the University of the Philippines Cebu. He has published more than 28 research articles in international peer-reviewed journals. He is an associate editor of the *International Journal of Applied Industrial Engineering*. He is a member of the International Honor Society of Phi Kappa Phi, the Institute of Electrical and Electronics Engineers (IEEE), and the National Research Council of the Philippines (NRCP). His research interests include computational intelligence, machine learning, data mining, and their applications.

1 Introduction

The coronovirus disease (COVID-19) pandemic has clearly caused a massive disruption across the globe (Brodeur et al., 2021). It has hampered countries in several dimensions including the economy, education, health, and even the environment (Kaye et al., 2021). While the most concerning aspect would be the sudden blow to the healthcare capacity of many countries, the economy of most countries, especially developing ones like the Philippines, was also heavily compromised. Among the economic dimensions affected by the COVID-19 pandemic is the employment rate in the country. As of 2019, before the pandemic, employment rate was recorded to be at a high 94.8% (Philippine Statistics Authority, 2020). This figure translates to around 41.8 million employed persons (Philippine Statistics Authority, 2020). However, with the surge of the COVID-19 pandemic, the employment rate fell to a low 82.4%, or an unemployment rate of 17.6%, which translates to around 7.23 million unemployed persons (Philippine Statistics Authority, 2020).

The primary reasons reported by Philippine Statistics Authority (2020) that cause the high unemployment rate are:

1 bad weather (0.1%)

2 temporary illness or disability (1.1%)

3 tired or believed no work is available (2.0%)

4 wait for rehire or job recall (3.7%)

5 awaiting results of previous job application (5.1%)

6 lockdown due to the COVID-19 pandemic (88.1%).

Clearly, the lockdown protocols constitute the most significant portion of the reasons of unemployment in the country. Subsequently, Philippine Statistics Authority (2020) reported that the self-employed population went up to 28.7% in April 2020 from 27.4% in April 2019. Interestingly, scholars found that a significant portion of the country's self-employed population is composed of freelancers (Philippine News Agency, 2020). The usual freelancing jobs in the country involve software development, online teaching and tutoring, and virtual assistance, among others (Philippine News Agency, 2020). In fact, the Philippines was noted to have one of the highest number of freelancers per capita, at around 2.0% or roughly 1.5 million to 2 million Filipinos since 2019. With this, policymakers in the country began drafting legal frameworks that will map out strategies to promote and strengthen digital careers and institutionalise employment standards for digital career workers (Philippine News Agency, 2020).

The establishment of these legal frameworks would indeed help formalise this sector in the country. However, with the lack of guidelines coming directly from those involved in freelancing jobs in the Philippines, developing a comprehensive framework would be challenging. Since these jobs are relatively new in the country, several parameters remain within the gaps of the literature. One of the crucial points that is not well understood in the literature is about the critical success factors (CSF) of freelancing. While works such as Reel (1999) and Sudhakar (2012) provide a good starting point for CSFs related to software development, to the best of the author's knowledge, no work has laid down the CSFs for software development freelancing.

However, understanding these CSFs and their potential relations would be crucial in the development of comprehensive policies regarding freelancing. In this paper, the CSFs for software development freelancing are studied. A focus group discussion was conducted among five experienced freelance software professionals to establish a list of relevant CSFs for freelance software development, as well as to determine the causal relationships among the CSFs.

An intuitionistic fuzzy decision making trial and evaluation laboratory (IF-DEMATEL) was adopted to analyse the causal relationships of the CSFs using the judgment elicited from the panel. The results of the study would be significant to the current literature in many ways. For one, the paper is the first to provide a list of CSFs for freelance software development in the literature. As such, scholars could use these CSFs to understand the dynamics of software development freelancing. The paper may also serve as a basis in forming CSFs for other freelance jobs, such as virtual assistance, and online tutoring, to name a few. Moreover, the study is the first to analyse the causal relationships of these CSFs using a soft computing approach. As such, the paper provides scholars in the literature with a methodological framework for analysing these CSFs. This study would be beneficial for stakeholders, such as policymakers and managers. For policymakers, the findings in the study could serve as basis for developing policies that would benefit freelancers in the Philippines, especially software developers. For managers, the findings in the study could aid in the design of effective management strategies that would improve the success of freelance software projects.

2 Literature review

2.1 What is freelancing?

The modern meaning of the term ‘freelancing’ began to be used in the second part of the 20th century (Gheorghe, 2015). The term was used to classify unaffiliated journalists “who provided on-demand services for various press organizations” (Gheorghe, 2015). However, the term was then used in other services that were delivered beyond the traditional employment connections, such as graphic design, marketing, advertising, legal consulting, and information technology, among others (Gheorghe, 2015). The occurrence of freelancing as a global phenomenon is influenced by the fast spread of internet connectivity across the many countries (Gheorghe, 2015). As such, freelancing has received considerable media policy and policy attention in recent years (Garin et al., 2020). Freelancing, however, is not considered a legal term in many countries (Garin et al., 2020). In paying taxes, freelancers are classified under self-employed entities (Garin et al., 2020). While this has been the case in most countries, freelancing and self-employment have distinct characteristics. For instance, self-employment usually entails hiring employees while freelancing involves only the freelancer (i.e., without employees) (van der Zwan et al., 2020). As such, freelancers lie in the grey area of being ‘entrepreneurs’ and ‘employees’ at the same time (van der Zwan et al., 2020). Moreover, freelancers differentiate themselves from self-employed entities by their preference for temporary work and the knowledge/skill-intensive services they provide (van der Zwan et al., 2020). As a result, freelancers suffer from uncertainty and riskiness surrounding their work. In spite of that, van der Zwan et al. (2020) found that the overall life

satisfaction of freelancers are not significantly different from other entities. In recent years, freelancing has propagated in the IT domain, such as in software engineering, mobile development, and web development, among others. However, its mechanism is not well understood in the current literature. With the proliferation of freelancing among software development projects, understanding its current state within the field would provide insights regarding its future dynamics.

2.2 Current state of software development freelancing

Software development has been one of the most progressive projects in the global market. For instance, in Pakistan, IT projects involving software development are continuously growing (Rehman et al., 2021). In fact, in 2017, more than 2,500 IT companies report growing recruitment of highly skilled and educated IT professionals registered in Pakistan (Rehman et al., 2021). In Bangladesh, the growth of IT freelancing has been evident, following the intensification of software development technology in the country (Alam et al., 2021). Furthermore, in the freelancing domain, software development accounts for around 43% of the demand and the remaining 57% is composed of jobs, such as clerical and data entry, creative and multimedia, writing and translation, and professional services, among others (Stephany et al., 2021). The majority of IT freelancing is sourced from India, which can be verified by its dominant market share of around 33% in 2021 (Stephany et al., 2021; Gheorghe, 2015). As such, India is considered as the major provider of freelance services in the global market. While developing countries are the usual locations for outsourcing software development freelancing services, developed countries, such as the USA, UK, Germany and Italy, have also made it to the top 15 countries with most freelancers in the IT domain (Stephany et al., 2021; Sawyer et al., 2020). By and large, however, these developed nations participate in the global market in the demand-side rather than in the supply-side (Popiel, 2017). The surge of the COVID-19 pandemic has changed the current landscape of software development freelancing at a global scale (Stephany et al., 2021; Sawyer et al., 2020). For example, Stephany et al. (2021) emphasised that while there was an unprecedent drop during the start of global lockdowns in March 2020, project requests spiked an all-time high in May 2020. Moreover, roughly 90% more projects were demanded via online freelance platforms in the early 2021 than in mid-2016, when the online labour index (OLI) was launched (Stephany et al., 2021). This translates to an annul growth rate of 10%, which is significantly higher than changes in national (on-site) labour markets (Stephany et al., 2021).

2.3 Critical success factors of software development

The demand for online freelancing in the software development domain has clearly demonstrated its growing importance in both the literature and society. However, software projects involve a high-level of complex characteristics, which complicate their management (Reel, 1999). For example, since software projects may deal with user requirements from non-specialists, a volatile mixture of management issues might arise (Reel, 1999). With these concerns at hand, software developers are usually very intelligent and complex individuals, which further complicates the management formula (Reel, 1999). These problems, along with other factors, contribute to high failure

rates of many software development projects (Reel, 1999). Since software projects are integral in many real-world systems, understanding the factors that would lead to their success would be crucial for the current literature. In relevant domains, these factors are termed *critical success factors* (CSFs) or *key success factors*. CSFs are factors that help identify the most important areas that need attention for the project to flourish (Yaghoobi, 2018; Ahimbisibwe et al., 2015). The CSFs for software projects have been studied in the current literature (Aldahmash et al., 2017). For instance, (Yaghoobi, 2018) studied the prioritisation of 15 key success factors for software projects, such as realistic budget, strong executive support, team size, and proper planning. Likewise, Aldahmash et al. (2017) studied eight CSFs for agile software development, such as delivery strategy, communication, and top management support. Last but not least, Sudhakar (2012) developed a model of CSFs for software projects, which consists of seven categories, such as communication factors, technical factors, organisational factors, and environmental factors, among others. While extensive works (e.g., Sudhakar, 2012; Chiyangwa and Mnkandla, 2017; Saleem, 2019) about the CSFs for software development have already been studied in the current literature, no study has been made regarding the CSFs of software development freelancing. As such, developing conceptual frameworks about software development freelancing, especially within the COVID-19 pandemic context, would provide a groundwork for understanding its dynamics.

2.4 Techniques for modelling critical success factors

Modelling CSFs has an extensive history in several fields in the literature. For instance, Bongo et al. (2020) developed a descriptive literature analysis of the CSFs of Industry 4.0 from an organisational point of view. Luthra et al. (2018) modelled the causal relationships of the CSFs for sustainability initiatives in supply chains using the Grey-Decision Making Trial and Evaluation Laboratory (G-DEMATEL). AlZawati et al. (2020) analysed the CSFs for implementing the United Arab Emirates' government excellence model in the public sector using an interpretative structural modelling (ISM) technique. Kineber et al. (2021) studied the relationship between value management's activities and CSFs for sustainable buildings using structural equation modelling (SEM). Last but not least, Maftei et al. (2016) modelled the CSFs of online music streaming services using the fuzzy cognitive map (FCM) method. While various approaches have been used to model and analyse CSFs in several applications, a common theme among such works is the development of causal models or frameworks. Developing these causal (or structural) models gives stakeholders and policymakers a clear grasp of the influence and relationships between the CSFs. In turn, it leads to the development of effective prioritisation, resource allocation, and other strategies, for facilitating the success of a program or an initiative. The DEMATEL method is one of the most widely used approach for causal modelling among CSFs for several reasons, such as:

1 it helps provide the mutual influences among different CSFs
2 it helps visualise the interrelationship among CSFs
3 it can be used to rank the CSFs according to their degree of influence and importance (Prakash et al., 2021).

The DEMATEL can also be used to separate the CSFs into cause and effect groups, which would be useful when stakeholders are interested in determining CSFs that would cascade to other CSFs (Prakash et al., 2021; Si et al., 2018). With this advantage, the DEMATEL has been extended to several decision-making environments in the literature to handle varying levels of uncertainty. For instance, Chai et al. (2022) used a fuzzy DEMATEL combined with FCM to identify the CSFs of building information modelling (BIM) software selection. Li et al. (2014) used an evidential DEMATEL method to identify the CSFs in emergency management. Moreover, Zhou et al. (2017) combined the DEMATEL method with D-number theory to analyse CSFS in emergency management. A systematic review by Si et al. (2018) discusses the several extensions made in the literature based on the DEMATEL method.

3 Methodology

3.1 Case background

The case study was conducted in Cebu (Philippines), being an information technology hub in the country. Five experienced freelance software professionals were invited purposively to form the panel of decision makers. First, relevant CSFs are extracted using a literature review. Afterwards, a panel of experienced professionals in software development freelancing is formed to judge the relevance of the CSFs. The panel members were selected using two criteria:

1 years of experience in freelancing

2 field of specialisation.

Since IT is a highly dynamic field and many developers jump from one job to another, the study considers developers with at least three years of experience in freelancing to constitute the panel. The field of specialisation of the panel members were diversified to invite different perspectives during the focus group discussion. The composition of the panel is presented in Table 1. A focus group discussion was conducted among the panel members to generate more relevant CSFs, judge relevance of the extracted CSFs, and decide the causal relationships among the finalised list of CSFs. The decision of the panel was established as a group; whenever a tie would exist, the concepts associated with the tie are re-evaluated to break the tie. As a result, 26 CSFs were established by the panel as presented in Table 2.

Table 1 Composition of the panel of experienced freelance software professionals with years of experience and field of specialisation

Panel member	*Years of experience*	*Professional experience*
Member 1	7 years	General software
Member 2	4 years	Mobile development
Member 3	3 years	Web development
Member 4	5 years	Desktop development
Member 5	3 years	Game development

Note: *General software* means that the member has worked as a freelance developer in various areas.

Table 2 Impact table of the critical success factors resulting from the IF-DEMATEL analysis

Item no.	*Critical success factor*	*Source*
0	Good location of project headquarters	Panel
1	Client has reached sufficient maturity in the project's domain	Panel
2	Project manager's competency	Reel (1999)
3	Project team member's competency	Reel (1999)
4	Good leadership of project manager as provided by reviews	Sudhakar (2012)
5	Commitments of project participants in meeting the project goals	Sudhakar (2012)
6	Client organisation has a track record of good coordination between project participants	Panel
7	Top management support	Sudhakar (2012)
8	Comprehensive contract documentation	Panel
9	Competitive procurement process	Sudhakar (2012)
10	Transparency in the procurement process	Panel
11	Project plan is clear and well-documented	Reel (1999)
12	Adequate use of communication among project participants	Panel
13	Clarity of project goals to the project team	Reel (1999)
14	Effective project monitoring	Sudhakar (2012)
15	Project team's motivation	Sudhakar (2012)
16	Project size	Panel
17	Project's perceived social impact	Panel
18	Client has accurate cost estimates of the project	Reel (1999)
19	Client offers realistic project schedule	Reel (1999) and Sudhakar (2012)
20	Client organisation has well-established procedures for timely execution of debugging/troubleshooting activities	Sudhakar (2012)
21	Client organisation has a track record of maintaining high quality work	Panel
22	End-user's perception of the project	Reel (1999)
23	Providing guarantee/support to freelancers (e.g., bills, laws, incentives)	Panel
24	Client provides additional incentives and benefits to contractor/freelancer	Panel
25	Client offers flexible work schedule	Panel

3.2 Intuitionistic fuzzy decision making trial and evaluation laboratory

The IF-DEMATEL is a soft computing causal modelling approach that combines intuitionistic fuzzy set (IFS) theory and multiple criteria decision making (MCDM). It has been used to analyse the relationships of concepts in a complex systems such as in developing green practices for supply chains (Govindan et al., 2015), prioritisation in insurance industry (Nikjoo and Saeedpoor, 2014), and strategic mapping for youth unemployment (Zhang et al., 2020), among others. The DEMATEL is the primary module for quantifying the causal relationships between the concepts while IFS provides a mathematical process for handling ambiguities, vagueness, and subjectivity in the decisionmakers' judgment. For a more comprehensive background about IFS

and DEMATEL, the reader is pointed to the work of Govindan et al. (2015). The IFS-DEMATEL used in this study is adopted from the algorithm presented by Govindan et al. (2015), but using a different linguistic scale calibrated by the panel. The procedure for the IF-DEMATEL is as follows:

Step 1 Develop a linguistic matrix of direct relations between the CSFs using the linguistic scale in Table 3. Given n CSFs, the linguistic matrix $L = [(l_i, l_j)]_{n\times n}$ is an $n \times n$ matrix of relations $e_{ij} = (l_i, l_j)$ such that e_{ij} quantifies the influence of CSF i to CSF j in linguistic scale.

Step 2 Obtain the intuitionistic fuzzy tensor Φ from the linguistic matrix L using Table 3. The intuitionistic fuzzy direct relation tensor is given by equation (1):

$$\Phi = \langle D_l, D_m, D_u, D_{l'}, D_{m'}, D_{u'} \rangle \tag{1}$$

where each element in the tensor is the direct relation matrix corresponding to the equivalent triangular IFS values expressed as $\langle (l, m, u), (l', m', u') \rangle$. These matrices are presented in equation (2) as follows:

$$\begin{aligned} D_l &= \begin{bmatrix} l_{11} \cdots l_{1n} \\ \vdots \ \ddots \ \vdots \\ l_{n1} \ldots l_{nn} \end{bmatrix} D_m = \begin{bmatrix} m_{11} \cdots m_{1n} \\ \vdots \ \ddots \ \vdots \\ m_{n1} \ldots m_{nn} \end{bmatrix} \quad D_u = \begin{bmatrix} u_{11} \cdots u_{1n} \\ \vdots \ \ddots \ \vdots \\ u_{n1} \ldots u_{nn} \end{bmatrix} \\ D_{l'} &= \begin{bmatrix} l'_{11} \cdots l'_{1n} \\ \vdots \ \ddots \ \vdots \\ l'_{n1} \ldots l'_{nn} \end{bmatrix} D_{m'} = \begin{bmatrix} m'_{11} \cdots m'_{1n} \\ \vdots \ \ddots \ \vdots \\ m'_{n1} \ldots m'_{nn} \end{bmatrix} \quad D_{u'} = \begin{bmatrix} u'_{11} \cdots u'_{1n} \\ \vdots \ \ddots \ \vdots \\ u'_{n1} \ldots u'_{nn} \end{bmatrix} \end{aligned} \tag{2}$$

Table 3 Linguistic scale for the intuitionistic fuzzy DEMATEL

Linguistic scale	*Code*	*Equivalent triangular intuitionistic fuzzy values*
Very high	VH	$\langle (0.8, 1, 1), (1, 1, 1) \rangle$
High	H	$\langle (0.6, 0.7, 0.8), (0.5, 0.7, 0.9) \rangle$
Low	L	$\langle (0.4, 0.5, 0.6), (0.3, 0.5, 0.7) \rangle$
Very low	VL	$\langle (0.2, 0.3, 0.4), (0, 0.1, 0.2) \rangle$
No relationship	N	$\langle (0, 0, 0), (0, 0, 0) \rangle$

Note: The equivalent triangular fuzzy values were calibrated by the panel before the elicitation of judgement.

Step 3 Calculate the IFS total relationship tensor $\Gamma = \langle T_l, T_m, T_u, T_{l'}, T_{m'}, T_{u'} \rangle$ for each element in the intuitionistic fuzzy direct relation tensor Φ, where each T_k is computed using equation (3) as follows:

$$T_k = D_k \left(I - D_k\right)^{-1} \tag{3}$$

Step 4 Defuzzify the total relation tensor Γ using equation (4) to obtain the total relation matrix Z as follows:

$$Z = \frac{T_l + 4 \cdot T_m + T_u + T_{l'} + 4 \cdot T_{m'} + T_{u'}}{12} \tag{4}$$

Step 5 A threshold ω can be applied to the crisp total relationship matrix Z in order to filter out negligible relationships. Calculate the adjacency matrix $A = [a_{ij}]_{n\times n}$ by applying the threshold ω to the elements of the crisp total relationship matrix $Z = [z_{ij}]_{n\times n}$ as in equation (5):

$$a_{ij} = \begin{cases} z_{ij}, & z_{ij} \geq \omega \\ 0, & z_{ij} < \omega \end{cases} \tag{5}$$

Step 6 Using the adjacency matrix $A = [a_{ij}]$, determine the *cause* CSFs and *effect* CSFs by analysing the driving power and receiving power of each CSF. For a given CSF υ, the driving power δ_υ is obtained using equation (6) and the receiving power Ψ_υ is obtained using equation (7):

$$\delta_\upsilon = \sum_{j=0}^{n-1} a_{\upsilon j} \tag{6}$$

$$\Psi_\upsilon = \sum_{j=0}^{n-1} a_{j\upsilon} \tag{7}$$

A CSF is classified into a *cause*, *effect*, or *neutral* using the following rules:

- if $\delta_\upsilon - \Psi_\upsilon > 0$ then υ is a *cause* CSF
- if $\delta_\upsilon - \Psi_\upsilon < 0$ then υ is an *effect* CSF
- if $\delta_\upsilon - \Psi_\upsilon = 0$ then υ is a *neutral* CSF.

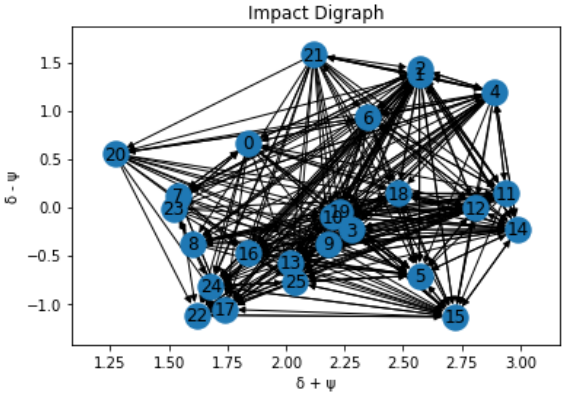
The CSFs can then be plotted on an impact digraph as in Figure 1 which depicts their causal interrelationships. The horizontal axis of the plot represents the $\delta_\upsilon + \Psi_\upsilon$, which can be interpreted as the relative importance of a CSF compared to other CSFs. The vertical axis of the plot represent whether a CSF is a cause, an effect, or neutral. In the adjacency matrix A, if an element $a_{ij} > 0$ then a directed edge exists from CSF i to CSF j. Otherwise, no edge exists.

4 Results and discussion

The focus group discussion among the panel members resulted into a list of 26 CSFs for software development freelancing in the Philippines as shown in Table 2. Using these CSFs, the panel formed the corresponding linguistic matrix. The linguistic matrix represents the causal influence of one CSF to another CSF. The linguistic matrix was then processed using the IF-DEMATEL algorithm. This process resulted into the impact table in Table 4. Furthermore, the impact digraph is presented in Figure 1. Several interesting insights can be derived from the results of the IF-DEMATEL in Table 4. First, there are only 10 net causes among the 26 CSFs whereas there are 16 net effects. The net causes are the CSFs that, in general, influence other CSFs in the system. Being a net cause means that for a given CSF, it influences more CSFs than being influenced

by other CSFs, while a net effect is the opposite. As such, if a net cause CSF is well facilitated, then the expected success would also cascade to the other CSFs in the system, especially those that are classified as net effects. Stakeholders must then ensure that these CSFs are observed in every freelance software development project. Since there are relatively fewer net causes compared to the net effects, stakeholders only have a few CSFs to monitor in order to ensure that the dynamics of freelance software development jobs in the Philippines are facilitated.

Figure 1 Impact digraph plot (see online version for colours)



Note: The horizontal axis of the plot represents the $\delta_v + \Psi_v$, which can be interpreted as the relative importance of a CSF compared to other CSFs. The vertical axis of the plot represent whether aCSF is a cause, an effect, or neutral. In the adjacency matrix A, if an element $a_{ij} > 0$ then a directed edge exists from CSF i to CSF j. Otherwise, no edge exists.

It can be inferred from the results in Table 4 that the net causes were mostly associated with the characteristics of the:

1 project manager

2 the client

3 top management.

For instance, in the project manager's side, project manager's competency (CSF 2) and good leadership of project manager as provided by reviews (CSF 4) were found to be net causes. In the client's side, client has reached sufficient maturity in the project's domain (CSF 1), client organisation has a track record of good coordination between project participants (CSF 6), client has accurate cost estimates of the project (CSF 18), client organisation has well-established procedures for timely execution of debugging/ troubleshooting activities (CSF 20), and client organisation has a track record of maintaining high quality work (CSF 21). Finally, top management support (CSF 7) and project plan is clear and well-documented (CSF 11) were also found to be net causes. These characteristics are clearly on the management-side. While the result is not very surprising, since the overall success of a project lies heavily on the management-side. However, it is important to note that the findings are consistent with

the findings in fields outside software development freelancing. Thus, it can be said that similar existing frameworks could be adopted to design guidelines that would apply to software development freelancing.

Table 4 Impact table of the critical success factors resulting from the intuitionistic fuzzy decision making trial and evaluation laboratory (IF-DEMATEL) analysis

Item no.	*Critical success factor*	δ_v	Ψ	$\delta_v + \Psi_v$	$\delta_v - \Psi_v$	*Nature*
0	Good location of project headquarters	1.25	0.59	1.84	0.66	Net cause
1	Client has reached sufficient maturity in the project's domain	1.97	0.60	2.57	1.38	Net cause
2	Project manager's competency	2.00	0.57	2.56	1.43	Net cause
3	Project team member's competency	1.02	1.26	2.28	–0.25	Net effect
4	Good leadership of project manager as provided by reviews	2.04	0.85	2.89	1.19	Net cause
5	Commitments of project participants in meeting the project goals	0.93	1.64	2.57	–0.71	Net effect
6	Client organisation has a track record of good coordination between project participants	1.64	0.71	2.34	0.93	Net cause
7	Top management support	0.83	0.71	1.54	0.12	Net cause
8	Comprehensive contract documentation	0.61	0.99	1.60	–0.38	Net effect
9	Competitive procurement process	0.90	1.28	2.18	–0.38	Net effect
10	Transparency in the procurement process	1.05	1.15	2.20	–0.10	Net effect
11	Project plan is clear and well-documented	1.54	1.40	2.94	0.14	Net cause
12	Adequate use of communication among project participants	1.40	1.41	2.81	–0.01	Net effect
13	Clarity of project goals to the project team	0.72	1.30	2.02	–0.58	Net effect
14	Effective project monitoring	1.38	1.61	2.99	–0.23	Net effect
15	Project team's motivation	0.79	1.93	2.72	–1.14	Net effect
16	Project size	0.68	1.16	1.84	–0.48	Net effect
17	Project's perceived social impact	0.34	1.40	1.74	–1.06	Net effect
18	Client has accurate cost estimates of the project	1.31	1.17	2.48	0.14	Net cause
19	Client offers realistic project schedule	1.09	1.14	2.23	–0.05	Net effect
20	Client organisation has well-established procedures for timely execution of debugging/troubleshooting activities	0.91	0.36	1.27	0.55	Net cause
21	Client organisation has a track record of maintaining high quality work	1.85	0.27	2.12	1.58	Net cause
22	End-user's perception of the project	0.25	1.37	1.62	–1.12	Net effect
23	Providing guarantee/support to freelancers (e.g., bills, laws, incentives)	0.75	0.77	1.52	–0.02	Net effect
24	Client provides additional incentives and benefits to contractor/freelancer	0.43	1.25	1.68	–0.82	Net effect
25	Client offers flexible work schedule	0.63	1.41	2.04	–0.78	Net effect

However, in addition to being mostly related to the management-side, good location of project head quarters (CSF 0) was found to be significant as well. Unlike the other net causes, this is not in the management-side but rather a geographical aspect. This is an important result in software development freelancing. Since Filipino freelance software developers usually accept jobs outside the Philippines, this means that there may be geographical locations that are more amenable to the conventional freelance setup in the Philippines (e.g., virtual/online). This is an important result that stakeholders such as policymakers must take note, as it can be used to draft relevant frameworks. For example, incentivising geographical locations that are mostly associated with freelance projects. While CSFs classified as net effects are not as urgent to be addressed as the net causes, they can be used as an indicator for assessing the overall dynamics of freelance software development in the Philippines as the net effects are usually much easier to observe than the net causes. For example, if a competitive procurement process is evident in a project, then it can be said that the net cause CSFs are well-addressed. As such, stakeholders could create an indicator system for evaluating projects using the CSFs classified as net effects.

The findings in this study would be significant to the current literature. One, by establishing a list of relevant CSFs, scholars and stakeholders could have a basis for evaluating the current state of freelance software development in a developing country like the Philippines, where the number of freelance workers has been growing, especially during the COVID-19 pandemic. Moreover, by analysing the causal relationships of the CSFs, the study offers insights about how the CSFs could be used to facilitate the dynamics of freelancing in a developing country. For scholars, the findings could be a basis for designing further works such as developing theoretical frameworks for software development freelancing, or freelancing in general. For stakeholders and policymakers, the findings could shed light on how the legal frameworks or guidelines may be designed in a way that would be truly beneficial for freelance software developers.

5 Conclusions and future works

This study investigates the critical success factors of freelance software development in the Philippines during the COVID-19 pandemic. As a result, 26 critical success factors were derived in the study. Using an IF-DEMATEL approach, the study finds that the management aspects:

1 project-side

2 top management-side

3 client-side.

Are the most prominent characteristics that drive the success of freelance software development projects in the Philippines.

The findings in this study would be significant to the current literature in many ways. First, by developing a list of relevant CSFs, scholars and stakeholders could have a basis for evaluating the current state of freelance software development. Furthermore, by analysing the causal relationships of the CSFs, the study offers insights about how the CSFs could be used to facilitate the dynamics of freelancing in a developing

country. For scholars, the findings could be a basis for designing further works such as developing theoretical frameworks for software development freelancing, or freelancing in general. For stakeholders and policymakers, the findings could shed light on how the legal frameworks or guidelines may be designed in a way that would be truly beneficial for freelance software developers. While the results of this study are significant, some limitations are worth emphasising. One, the study uses expert decision making. As such, results are not guaranteed to be safely generalisable to the population. While expert decision making has been shown to provide rich insights, models based on random sampling (e.g., factor analysis) would generate more powerful results. In future works, scholars could adopt a more powerful research design (e.g., population-based) to further analyse the critical success factors.

References

Ahimbisibwe, A., Cavana, R.Y. and Daellenbach, U. (2015) 'A contingency fit model of critical success factors for software development projects: a comparison of agile and traditional plan-based methodologies', *Journal of Enterprise Information Management*, Vol. 28, No. 1, pp.7–33.

Alam, S., Hasan, A.R. and Borman, T. (2021) 'It freelancing in Bangladesh: assessment of present status and future needs', *Journal of Economics and Business*, Vol. 4, No. 1, pp.33–56.

Aldahmash, A., Gravell, A.M. and Howard, Y. (2017) 'A review on the critical success factors of agile software development', *European Conference on Software Process Improvement*, Springer, pp.504–512.

AlZawati, O.K., Bashir, H. and Alsyouf, I. (2020) 'Modelling and analyzing of critical success factors for implementing UAE's government excellence model in the public sector: an ISM and fuzzy-MICMAC approach', *International Journal of System Assurance Engineering and Management*, Vol. 11, No. 6, pp.1107–1132.

Bongo, M., Abellana, D.P., Caballes, S.A., Ancheta Jr., R., Himang, C., Obiso, J-J., Ocampo, L. and Deocaris, C. (2020) 'Critical success factors in implementing Industry 4.0 from an organisational point of view: a literature analysis', *International Journal of Advanced Operations Management*, Vol. 12, No. 3, pp.273–301.

Brodeur, A., Gray, D., Islam, A. and Bhuiyan, S. (2021) 'A literature review of the economics of COVID-19', *Journal of Economic Surveys*, Vol. 35, No. 4, pp.1007–1044.

Chai, Q., Li, H., Tian, W. and Zhang, Y. (2022) 'Critical success factors for safety program implementation of regeneration of abandoned industrial building projects in China: a fuzzy DEMATEL approach', *Sustainability*, Vol. 14, No. 3, p.1550.

Chiyangwa, T.B. and Mnkandla, E. (2017) 'Modelling the critical success factors of agile software development projects in South Africa', *South African Journal of Information Management*, Vol. 19, No. 1, pp.1–8.

Garin, A., Jackson, E., Koustas, D.K. and McPherson, C. (2020) 'Is new platform work different from other freelancing?', *AEA Papers and Proceedings*, Vol. 110, pp.157–161.

Gheorghe, M. (2015) 'State of freelancing in it and future trends', *International Journal of Economics and Management Engineering*, Vol. 9, No. 5, pp.1474–1478.

Govindan, K., Khodaverdi, R. and Vafadarnikjoo, A. (2015) 'Intuitionistic fuzzy based DEMATEL method for developing green practices and performances in a green supply chain', *Expert Systems with Applications*, Vol. 42, No. 20, pp.7207–7220.

Kaye, A.D., Okeagu, C.N., Pham, A.D., Silva, R.A., Hurley, J.J., Arron, B.L., Sarfraz, N., Lee, H.N., Ghali, G.E., Gamble, J.W. et al. (2021) 'Economic impact of COVID-19 pandemic on healthcare facilities and systems: international perspectives', *Best Practice & Research Clinical Anaesthesiology*, Vol. 35, No. 3, pp.293–306.

Kineber, A.F., Othman, I.B., Oke, A.E. and Chileshe, N. (2021) 'Modelling the relationship between value management's activities and critical success factors for sustainable buildings', *Journal of Engineering, Design and Technology*, Vol. 20, No. 2, pp.414–435.

Li, Y., Hu, Y., Zhang, X., Deng, Y. and Mahadevan, S. (2014) 'An evidential DEMATEL method to identify critical success factors in emergency management', *Applied Soft Computing*, September, Vol. 22, pp.504–510.

Luthra, S., Mangla, S.K., Shankar, R., Garg, C.P. and Jakhar, S. (2018) 'Modelling critical success factors for sustainability initiatives in supply chains in Indian context using grey-DEMATEL', *Production Planning & Control*, Vol. 29, No. 9, pp.705–728.

Maftei, V.A., Gerogiannis, V.C. and Papageorgiou, E.I. (2016) 'Critical success factors of online music streaming services – a case study of applying the fuzzy cognitive maps method', *International Journal of Technology Marketing*, Vol. 11, No. 3, pp.276–300.

Nikjoo, A.V. and Saeedpoor, M. (2014) 'An intuitionistic fuzzy DEMATEL methodology for prioritising the components of SWOT matrix in the Iranian insurance industry', *International Journal of Operational Research*, Vol. 20, No. 4, pp.439–452.

Philippine News Agency (2020) *Angara Sees Growth of Digital Careers in PH after COVID-19* [online] https://www.pna.gov.ph/articles/1103106 (accessed 20 February 2023).

Philippine Statistics Authority (2020) *Employment Situation in April 2020* [online] https://psa.gov.ph/statistics/survey/labor-and-employment/labor-forcesurvey/title/Employment%20Situation%20in%20April%202020 (accessed 20 February 2023).

Popiel, P. (2017) "Boundaryless' in the creative economy: assessing freelancing on upwork', *Critical Studies in Media Communication*, Vol. 34, No. 3, pp.220–233.

Prakash, S., Jasti, N.V.K., Chan, F., Sharma, V.P., Sharma, L.K. et al. (2021) 'Decision modelling of critical success factors for cold chains using the DEMATEL approach: a case study', *Measuring Business Excellence*, ahead-of-print.

Reel, J.S. (1999) 'Critical success factors in software projects', *IEEE Software*, Vol. 16, No. 3, pp.18–23.

Rehman, Z., Usman, M., Abrar, M.F. and Ullah, N. (2021) 'Freelancing as an alternative market for software professionals in Pakistan', *VFAST Transactions on Software Engineering*, Vol. 9, No. 3, pp.78–92.

Saleem, N. (2019) 'Empirical analysis of critical success factors for project management in global software development', *2019 ACM/IEEE 14th International Conference on Global Software Engineering (ICGSE)*, IEEE, pp.68–71.

Sawyer, S., Dunn, M., Munoz, I., Stephany, F., Raheja, R., Vaccaro, G. and Lehdonvirta, V. (2020) 'Freelancing online during the COVID-19 pandemic', *New Future of Work '20*, 3–5 August [online] https://www.microsoft.com/en-us/research/publication/freelancing-online-during-the-covid-19-pandemic.

Si, S-L., You, X-Y., Liu, H-C. and Zhang, P. (2018) 'DEMATEL technique: a systematic review of the state-of-the-art literature on methodologies and applications', *Mathematical Problems in Engineering*, Vol. 2018, pp.1–33.

Stephany, F., Kässi, O., Rani, U. and Lehdonvirta, V. (2021) 'Online labour index 2020: new ways to measure the world's remote freelancing market', *Big Data & Society*, Vol. 8, No. 2, p.20539517211043240.

Sudhakar, G.P. (2012) 'A model of critical success factors for software projects', *Journal of Enterprise Information Management*, Vol. 25, No. 6, pp.537–558.

van der Zwan, P., Hessels, J. and Burger, M. (2020) 'Happy free willies? Investigating the relationship between freelancing and subjective well-being', *Small Business Economics*, Vol. 55, No. 2, pp.475–491.

Yaghoobi, T. (2018) 'Prioritizing key success factors of software projects using fuzzy AHP', *Journal of Software: Evolution and Process*, Vol. 30, No. 1, p.e1891.

Zhang, G., Zhou, S., Xia, X., Yüksel, S., Baş, H. and Dincer, H. (2020) 'Strategic mapping of youth unemployment with interval-valued intuitionistic hesitant fuzzy DEMATEL based on 2-tuple linguistic values', *IEEE Access*, Vol. 8, pp.25706–25721.

Zhou, X., Shi, Y., Deng, X. and Deng, Y. (2017) 'D-DEMATEL: a new method to identify critical success factors in emergency management', *Safety Science*, January, Vol. 91, pp.93–104.