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Pretesting Impact of Operational Complexity in Malaysia's Electrical and Electronics Manufacturing Industry

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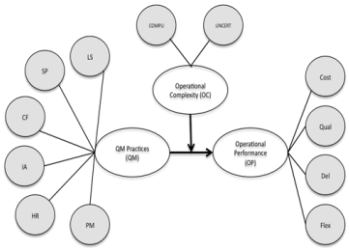
Graphical abstract



Abstract

Scientific research requires data collection instrument that is valid and reliable. This paper describes the framework and operationalization of the variables before outlining the process of developing the instrument to assess the impact of operational complexity (OC) on quality management (QM) practices and operational performance (OP) relationships in Malaysia's Electrical and Electronics (E&E) manufacturing industry. It also highlights issues of common method bias, reliability and validity of the instrument, pretest method and response rate. The pretest result is then discussed. The paper concludes that personal interviews are especially effective in detecting ambiguity in the instrument. Pilot run provides insights to the challenges ahead such as low response rate, tedious data analysis procedures and enables informed decision to be made in preparation for full-scale data collection.

Keywords: Operational complexity; quality management; questionnaire development; pretest; pilot test

Abstrak

Kajian saintifik memerlukan instrumen pengumpulan data yang sah dan boleh dipercayai. Kertas kerja ini menerangkan rangka kerja dan pengoperasian pembolehubah serta proses membangunkan instrumen untuk menilai kesan kerumitan operasi (OC) ke atas amalan pengurusan kualiti (QM)-prestasi operasi dalam industri pembuatan elektrik dan elektronik (E & E) di Malaysia. Ia juga mengetengahkan isu-isu *common method bias*, kebolehpercayaan dan kesahan instrumen, kaedah pra-ujian dan kadar respons. Hasil pra-ujian kemudiannya dibincangkan. Kesimpulannya, temu bual secara peribadi sangat efektif untuk mengesan kekeliruan soalan di instrumen. Kajian perintis pula dapat membantu penyelidik membuat persediaan yang teliti untuk menangani kadar respons yang rendah dan proses analisis yang rumit di peringkat pengumpulan data secara besar-besaran nanti.

Kata kunci: Kerumitan operasi; pengurusan kualiti; pembangunan soal selidik; pra-ujian; ujian perintis

1.0 INTRODUCTION

Manufacturing is an important sector for many developing countries for its significant contribution to the economy and creation of jobs. In Malaysia, manufacturing products constituted 72.5% of Malaysia total export products and the leading sub sector is the E & E products. It contributes to 31% of overall manufacturing output and 33.7% employment [1]. The Malaysia E & E manufacturing industry consists of 2 types of businesses, the original equipment maker (OEM) and the contract manufacturer (CM). There are also those who are both OEM and CM. The outsourcer is known as the OEM, who consigns the CM to perform some of its manufacturing operations [2]. Successful implementation of outsourcing has been proven to reduce costs [3-6]. In some literature, quality is also listed as one of the many benefits of outsourcing [6-8]. In this view, CM is viewed as the expert in the process hence, it is expected to produce higher quality than the OEM could achieve alone [7]. However, there are mixed findings whether outsourcing could improve quality [9]. Operating in CM environment requires flexible production system and strong supply chain management. Traditional manufacturing operations in an OEM only focus on single requirement, high volume and specific range of products. While CMs handle diverse customers with various requirements and expectations, low volume high mix products and fast delivery. Hence, OEM and CM have distinct operation characteristics [10]. In short, CM has a higher operational complexity (OC) compared to OEM [10]. Meanwhile, in the QM literature, there are mixed findings in the relationship between QM practices and performance [11]. These mixed results in the literature led to the perspective that effective QM practices are contingent to individual organization [11]. It is not a direct positive practice-performance relationship but there may be moderating variables between them, which are consistent with organization contingency theory [12].

1.1 Research Framework

In this study, the 3 main variables are QM practices, OC and Operational Performance (OP). QM practices is the independent variable (IV), OC is the moderating variable (MV) and OP is the dependent variable (DV). OC has been identified as the third variable that moderates the relationships of QM practices and OP. The study hypothesized that QM practices-OP relationship will be weaker when OC is high and become stronger when OC is low. The framework is as shown in Figure 1.

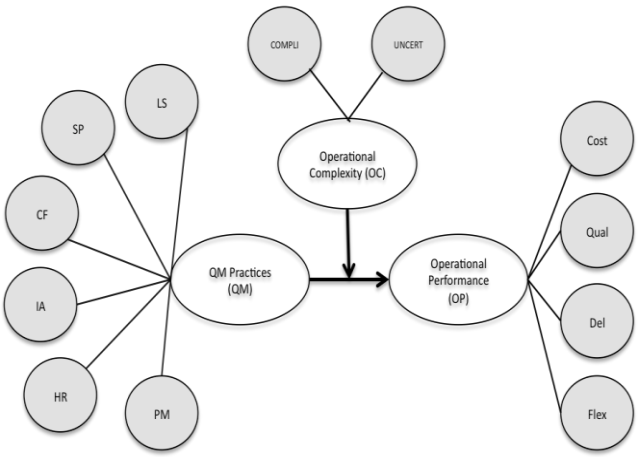


Figure 1 Framework

The rationales to support OC as the moderator are:- (1) there are mixed findings from the literature on the relationship between QM practices and performance (2) OC occurs at the same time with QM practices. These rationales are according to the moderator criteria as stated by [13].

1.2 Operationalization of QM Practices

QM practices is the IV that are operationalized by 6 dimensions adapted from the Malcolm Baldridge National Quality Award (MBNQA) framework. Various scholars have empirically tested the framework and it has proven to be robust [14] with excellent goodness of fit [15, 16]. The dimensions are: -

- Leadership (LS) - Examine level of senior management participation in setting the strategic directions, mission, vision of the organization to create conducive working environment that facilitate learning and high performance.
- Strategic Planning (SP) - Examine the effectiveness of organization in carrying out its planning and business strategies. It includes selection of objectives, deployment and measurement of progress.
- Customer Focus (CF) - Access how well organization determine and fulfilling customer requirements and expectations in terms of relationship management, quality of information exchange and handling of customer complaints.
- Information and Analysis (IA) - Access how organizations collect, analyze and utilize information to maintain customer focus, improve processes and performance. It includes the quality of data and information.
- Human Resource Focus (HR) - Examine how well the organizations develop and utilize human resource potential in line with organization missions. Evaluate whether organizations 'listen' to their employees. It includes training, communication and level of involvement and satisfaction of employees.
- Process Management (PM) - Examine key processes in product development, handling of product change and the supply chain processes from suppliers until delivery of final product.

1.3 Operationalization of Operational Performance

OP is the DV and it is operationalized by cost, quality, delivery and flexibility [12]. The dimensions are conceptualized as follows: -

- Cost (Cost) refers to the unit cost of manufacturing and cycle time from raw material to delivery [12, 17].
- Quality (Qual) refers to both internal and external performance; namely internal product conformance and external customer complains as well as perceived level of customer satisfaction [18, 19].
- Delivery (Del) refers to how often delivery are made on time in full to the customers and whether it can achieve to deliver ahead of time to customer [12] [20] [21].
- Flexibility (Flex) refers to the how fast is the cycle time to change model or volume from the notice given by customer [12, 17].

1.4 Operationalization of Moderating Variable

OC is the moderating variable. According to [22] by adopting [23] seminal work in information processing model, complicatedness and uncertainty are the 2 dimensions in OC.

- Complicatedness (COMPLI) refers to the extent of type of interactions in the system and viewed as a deterministic component related to numerousness and variety in the system [22].
- Uncertainty (UNCERT) is the extent of reliability and accuracy of the system. It also refers to the difference between the amount of information required to perform a task and the amount of information already possessed by the company [23].

For example, CM has high OC when uncertainty is created by frequent interruptions and influence from customers over operational decisions. This in turn created high intensity of exchange of information across all levels that eventually leads to higher amount of information that needs to be processed and complicates decision-making [23].

■2.0 MATERIAL AND METHODS

The instrument to measure the variables is a structured questionnaire. Questionnaire is a set of questions devised to assist data collection process in a form of survey [24]. It is the most common type of data collection in field research [25]. According to Churchill (1979) as quoted in [26], in general, there are 7 steps in questionnaire-development process. It starts with (1) specifying the information that are needed, (2) type of questionnaire and method of administration, (3) content of individual questions, (4) form of response to each question, (5) the number of questions and its sequence, (6) re-examine all the steps from (1)-(5) and revise if necessary and finally, (7) pretest the questionnaire and revise if necessary. During the process of development, the most important criteria are reliability and validity of the instrument.

Hence, once the questionnaire has been developed it will be subjected to reliability and validity testing.

2.1 The Questionnaire

By referring to the steps outlined by Churchill (1979) as quoted in [26], information needed for the questionnaire is guided by the objectives of the study. The main objective of this study is to assess the relationships among QM practices, OC and OP in Malaysia E & E manufacturing industry. Hence, primary data will be obtained directly from respondents via structured questionnaire to capture their perception on the issue. The respondents shall be the representatives from Malaysia E & E manufacturing companies holding the managerial position and directly involve with decision-making process of daily operations. Hence, the unit of analysis is the company. The form of responses is closed questions so as to ease the respondents in making quick decisions to choose from a list of options. The wordings and phrases have been carefully chosen in order to make it short, simple and clear. The overall design of the questionnaire takes heed of the recommendations from leading scholars such as [27] and [28]. The considerations include avoiding double barreled questions, leading questions, loaded questions, questions prone to socially desirable answers and involved distant recall answers. The format is designed to make it pleasant and interesting in order to have good response rate. Funnel approach is adopted whereby section seeking the personal information of the respondent is place at the very end of the questionnaire.

The questionnaire consists of 4 sections, namely QM practices, operational performance, operational complexity and general information. The first section forms the main part of the overall questionnaire. The original questionnaire has 36 measurement items or questions; covering the 6 QM practices dimensions of leadership, strategic planning, customer focus, information and analysis, human resource focus and process management. The measurement items are either adopted or adapted from the literature as shown in Table 1.

Table 1 Measurement items for QM practices

Dimension	Number of Items	References (Adopt)	References (Adapt)
Leadership (LS)	7	[29-32]	[14] [21, 29] [33]
Strategic Planning (SP)	6	[14] [21] [32]	[21, 29] [14]
Customer Focus (CF)	6	Not applicable	[21, 29] [33] [21, 32]
Information and Analysis (IA)	5	[14, 29]	[31]
Human Resource Focus (HR)	6	[21] [30]	[21]
Process Management (PM)	6	Not applicable	[30] [31]

A 7-point Likert scale has been chosen to capture the responses from the respondent on the level of their agreement with each positive worded statement. The rating scales range from (1) Strongly Disagree, (2) Disagree, (3) Slightly Disagree, (4) Neutral, (5) Slightly Agree, (6) Agree, and (7) Strongly Agree.

The second section is to measure the perceptions on OP based on cost, quality, delivery and flexibility. Respondents are asked to compare their performance with the industry norms. Since the respondents are from various sizes of companies manufacturing different types of product, the comparison to their respective industry norms hopes to ease them in providing the responses. A 5-point Likert scale is used ranging from (1) Poor, (2) Below average, (3) Average, (4) Above average and (5) Superior. Respondents are also asked to rate the strategic goals of cost, quality, delivery and flexibility according the level of importance using 5-point Likert scale. The scale ranges from (1) Not at all important, (2) Not so important, (3) Neutral important, (4) Important and (5) Very important. The score will then be used as the weightage to calculate the final overall score for operational performance. There are 10 measurement items for operational performance and 4 items for strategic goals. The items are either adopted or adapted from literature as shown in Table 2. The third section of the questionnaire is to measure the perceptions on OC. A total of 6 measurement items were developed based on literature as shown in Table 3. The respondents were asked to rate the level of complexity of their operations. A 7-point Likert scale is used to indicate the responses ranging from (1) Very low, (2) Slightly low, (3) Low, (4) Neutral, (5) Slightly high, (6) High and (7) Very high.

Table 2 Measurement items for operational performance

Dimension	Number of Items	References (Adopt)	References (Adapt)
Cost	4	[12] [16]	[21]
Quality (Qual)	2	Not applicable	[12, 34] [21, 34]
Delivery (Del)	2	[12, 21]	[12]
Flexibility (Flex)	2	[12]	Not applicable
Strategic Goals	4	[12, 35]	Not applicable

Table 3 Measurement items for Operational Complexity

Dimension	Number of Items	References (Adopt)	References (Adapt)
Complicatedness	3	Not applicable	[10, 22, 36] [37]
Uncertainty	3	Not applicable	[10, 22, 38, 39] [40]

Finally, the last section is to capture the demographic information of the respondents. This includes the type of business, type of ownership, size of company according to the number of employees, type of product, number of years in operation and list of acquired certifications.

2.2 Validity and Reliability of Instrument

Validity refers to the degree to which the instrument measures what it is supposed to measure [30] or the accuracy of the measurement [41]. Reliability refers to ability of the instrument to measure consistently over time despite of testing conditions or the state of the respondents [27]. It simply means that the instrument that has been developed must be measuring the variables accurately (validity) and consistently (reliability). In this study, content validity is ensured through adapting and adopting the measurement items from existing literature. Nevertheless to ensure the items can be understood in the local context, expert validation has been conducted too. This process is part of pretesting the instrument. In this study, a group of academics and industry experts were interviewed to seek their expert opinions whether all the questions (measurement items) really represent each construct correctly and if the questions can be easily understood. The result will be discussed in the next section.

Construct validity measures whether the items belong to the construct and whether the items that measure the construct has solid theoretical foundation and if it measures the theoretical construct that it was intended to measure [30]. Generally, it can be assessed through convergent and discriminant validity that can be tested using correlational analysis and factor analysis based on the data collected [27]. Convergent validity is how much an item correlates positively with other items in the same construct. The statistical measures to evaluate convergent validity are through the value of average variance extracted (AVE) and the loadings of each item [42]. A value of more than 0.50 for AVE and 0.70 for loadings of each item are deemed appropriate [42]. Discriminant validity refers to how much a construct is really unique to other constructs in the framework [42]. Hence, the implication is to ensure no two constructs are measuring the same perception. [42] proposes 2 measures to evaluate discriminant validity (1) loadings on each item in a construct should be higher than all cross loadings with other constructs (2) The squared root of AVE of each construct should be more than the highest correlation with any other construct as per the Fornell-Larcker criterion.

Meanwhile measuring the internal consistency of measures can test the reliability of the instrument and there should be high correlations among the items that measure the same construct. According to [27], the most widely accepted measure is the Cronbach's alpha. Generally, the accepted value is more than 0.80 for adapted instrument [43]. However, according to [42] Cronbach's alpha has a limitation of underestimating the internal consistency because it assumes that all items have equal outer loadings or equally reliable [42]. [42] suggests instead adopting a measure known as composite reliability (CR) whereby it considers the different in outer loadings of each items. The accepted value is 0.70 to 0.90 for non-exploratory research [43]. Nevertheless both Cronbach's alpha and CR are the accepted measures to evaluate reliability of an instrument.

2.3 Common Method Bias

There is a growing concern on the effect of potential method bias on the validity and reliability of the instrument [44]. It is especially critical when a single respondent answers all questions in a self-administered questionnaire [45]. Method bias which is also known as common method bias arise from "response tendencies that raters apply across measures,

similarities in item structure or wording that induce similar responses, the proximity of items in an instrument, and similarities in the medium, timing, or location in which measures are collected." [46]. It is the variance attributed to measurement method rather than variance explained by the construct [47]. The damages that common method bias could induce are causing bias estimates of construct reliability and validity as well as parameter estimates of the relationship between 2 constructs [44].

In designing the questionnaire, a different measurement scale, 7 point Likert scale for IV, MV and 5 point Likert scale for DV were adopted as remedy to prevent common method bias as per the recommendation by [47], [48]. However, the study could not implement collecting data from different sources for each questionnaire due to the limitation of low response rate of Malaysian companies. It has been reported that Malaysian companies tend to be less responsive to survey exercises and in general, the response rate is around 10% to 20% [49]. Nevertheless, with the awareness of the potential detrimental effect of common method variance (CMV), it is essential to follow up with statistical means to verify the bias. Harmon's single factor test is the widely accepted measure to detect evidence of common method bias [47]. The procedure is to input all items into a single factor and run principal component analysis (PCA) with un-rotated factor solution. If the test results showed that none of the construct constituted more than 50% of the total variance in the model, then common method bias is not evident.

2.4 Pretest

Pretesting is the final stage in instrument development process to determine how the questionnaire works on a small pilot study before a full-scale study is being conducted [26]. It is the best way to test how well the instrument is designed to communicate with ordinary people. According to [26], pretest includes testing of the length, layout, sequence and format of the instrument. Also, the clarity and difficulty of the questions and finally, pretesting the data analysis procedures by conducting a pilot run. The methods to administer pretesting are personal interview, telephone interview and mail self-reports. Personal interview is recommended as it enables the interviewer to observe the reactions from the respondents when answering the questionnaire. Hesitation on certain questions would indicate that there might be problem with the question [26]. According to [26] there are two methods in personal interview, the protocol method and debriefing method. In the protocol method, the respondent is asked to express his or her view as he or she is trying to answer the questionnaire. The interviewer then records what the respondent has commented. Meanwhile in the debriefing method, the respondent is asked to fill up the questionnaire without interruption and the interviewer will carefully observe the reaction or body language from the respondent. The interviewer will seek the respondent's comments once he or she has completed answering the questionnaire. Either method can be used depending on the preference of the respondents.

3.0 RESULTS AND DISCUSSION

3.1 Results of Expert Validation

In this study, a group of experts consisting of 4 academics and 4 practitioners were involved in pretesting the instrument. The selection of experts from both academic and industry is to give a balance comprehensive review of the instrument. Based on the literature, there is no consensus on the number of sample. The recommendation ranges from small, 12, 20 and 30 [26]. Personal interviews were conducted with 4 academics and 3 practitioners. Meanwhile 1 practitioner responded using self-report email. Both debriefing and protocol methods were used during the interviews. The interviews were mainly guided by the following questions: -

- Are the statements clear and easily understood?
- Do you think the statements are measuring the concept/ construct?
- Do you find difficulty in responding to the questionnaire?
- Are you comfortable in responding on the scale of 1-7?
- What do you think of the format of the questionnaire?

After completing the interviews, it can be observed that the comments could be classified under inappropriate use of terminology, double-barreled question, ambiguous question, ideal question and scope. Even though all the questions are either adopted or adapted from the literature, the highest number of comments is ambiguous question followed by inappropriate use of terminology and double-barreled question. The experts also pointed out lack of measurement items measuring OC. The results and explanation of each classification is as per Table 4. However, only selected comments are reported here to give examples of each classification.

Table 4 Results of interview

Classification	Explanation	No. of comments	Selected comments
Terminology	Inappropriate used of terminology. The term may be common in academic writing but not in local E &E manufacturing industry.	21	• "Leadership team is not suitable for Malaysian context use the term Management". • "Product mix is not a common term in local industry."
Double- barreled	Requires answer for more than two issues in one question at a time.	20	• "One statement consists of two issues, planning and review…" - e.g 'We have comprehensive and structured planning process that regularly sets and reviews short term and long-term goals.'
Ambiguous	Unclear and confusing statement.	30	• "Which part of the plan?..." – e.g 'Our employees know the parts of company's plans that will affect their work.'; • "How fast is fast, is it ahead of schedule?"e.g 'Fast delivery';

Classification	Explanation	No. of comments	Selected comments
Scope	Extent of coverage for issue highlighted in the statement.	12	• "Complexity only relates to new product release; suggest to include product variety, manufacturing system complexity, operator task complexity, supervisory task complexity, man-machine interface effectiveness"; to measure operational complexity.
Ideal	Statement is too ideal and is not happening in real world.	6	• "In the real world, usually only suppliers are required to improve their processes…" – e.g 'We work closely with our suppliers to improve each other's processes.'
Others		10	• "Inconsistent use of measurement scale.." • "Questionnaire contains too many pages, suggest to reduce font size and make it into double sided page…"

After careful consideration, all the ambiguous questions have been rectified, 2 items were deleted from QM practices from the dimension of leadership and strategic planning and 4 new items were added into OC to reflect the complicatedness and uncertainty dimensions. The decision is based on supporting literature after being highlighted by the experts during the interviews. The final questionnaire consists of 66 questions.

3.2 Results of Pilot Run

A pilot test is conducted to check the clarity of measurement items, item difficulty, internal consistency, response rates and parameter estimation [50]. A total of 40 emails containing the link to the online questionnaire were sent to potential respondents from the E & E manufacturing industry using convenient sampling method. Out of the 40 emails, 17 responded and answered all questions registering a response rate of 42% after a close follow up. The data is then coded and analyzed using Statistical Package for Social Science (SPSS) software version 20. The descriptive statistics function is used to summarize the respondents' profiles. About 40% of the respondents are from the OEMs and 60% are from the mixture of CMs with OEM cum CM companies. The majority (70%) of the respondents are 100% foreign owned companies, followed by joint venture (17%) and 100% local (12%). Most of the companies (80%) are large size with more than 150 full time employees. Meanwhile, types of products manufactured range from single product type to 9 different product type, 40% of the respondents' companies manufactured single product type and 60% of the companies manufactured on average 3 different types of product. All of the respondents' companies have acquired at least one ISO certification. Number of certification acquired ranges from 1 to 5 types of certifications. Almost all are certified with ISO 9001 followed by ISO 14000. This is expected since majority (70%) of the companies have been in operation for more than 5 years and 30% of them has been operating between 1 to 5 years. The subsequent function is the dimension reduction function in SPSS. It is to measure the internal consistency of the instrument. Even though the results showed that all the constructs have Cronbach's alpha value of more than 0.80 it cannot be justified, as the sample size is only 17. Nevertheless, the test run gives an insight on the challenges ahead in data analysis and enables preparation to be made before embarking into full-scale data collection and analysis.

3.3 Response Rate

In this pilot run, the response rate of 42% may seem high but in actual, the respondents are the authors' acquaintances that are working in the industry. The responses were obtained after a close follow up and it was not an easy task. This experience indicates that it will be a challenge to obtain high response rate in full-scale data collection later. The response rate of 10% to 20% for mail survey in Malaysia is considerably low in comparison with 35.7% response rate for organizational research published in top journals from year 2000 to 2005[51]. In view of the impending low response rate, strategies are put in place before the start of full- scale data collection. The first strategy is to be prepared to adopt all possible data collection techniques, which are, hardcopy mail survey, email/web-based survey and personal interviews. There will also be an invitation to the respondents to participate in a lucky draw. The web-based survey will be sent via email invitation and hosted at http://www.questionpro.com. This paid online survey service enables personalized email invitation to the targeted respondent with a professional outlook form. It also has the tracking feature to enable reminders to be sent to only those who did not respond, calculation of response rate and easy management on mailing list. The email invitation includes a legitimate link to the profile of the sender so as to assure the targeted respondents that it is not a spam or hoax. Hardcopy survey will be sent by post with self returned post paid envelope and interviews will be conducted at Trade Fairs or Career Fairs where some of the potential respondents may take part. The second strategy is to stratify the population (E & E companies) according to the geographical regions in Malaysia as in disproportionate stratified random sampling technique that the study is adopting. By anticipating a response rate of 15% and by referring to the method suggested by [52], in order to achieve minimum sample size of 80, a total of 533 questionnaires need to be distributed to potential respondents. The calculation is as follows: -

Total drawn samples = Minimum sample size / anticipated response rate

Hence, the questionnaire distribution in each region is as shown in Table 5.

Table 5 Distribution of questionnaire

State	Region	No. of companies	No. of minimum targeted respondent	No. of Questionnaire to be sent
Selangor	Central	365	34	227
Kuala Lumpur	Central	45	4	27
Pahang	East coast	9	1	7
Terengganu	East coast	5	0	0
Kelantan	East coast	1	0	0
Sabah	East Malaysia	4	1	4
Sarawak	East Malaysia	3	0	3
Pulau Pinang	Northern	158	15	100
Kedah	Northern	51	5	33
Perak	Northern	45	4	27
Johor	Southern	114	10	67
Melaka	Southern	40	4	27
Negeri Sembilan	Southern	18	2	14
Total		858	80	536*

** based on round up figure for each region*

4.0 CONCLUSION

Developing a valid and reliable instrument is crucial to ensure that proposed solution is based on scientific research that is replicable and rigorous. It can be observed that even though the questions are either adapted or adopted from the literature, there are still a number of relevant issues detected during pretesting especially industry terms that are uncommon in the local context. Apart from that, personal interviews using either the debriefing or protocol method was very effective in identifying ambiguous questions. The reaction from the respondents while attempting to understand the questions gave a very clear indication. By going through the pretest process, eventually, the researcher would know how many samples are needed. When the interviewee seemed to be giving similar comments even though the interview was conducted individually at different time, it is the indication that the samples are enough. In this study, it is found that after interviewing the 3rd expert from the same background similar concerns were raised. Even though there are growing debates on the number of sample for pilot run especially when it is used to interpret statistical results, it is still recommended to carry out. The pilot data collected are useful to test run data analysis procedure while the pilot data collecting process would give the feel of the response rate. In conclusion, apart from evaluating and validating the content of the questionnaire, the pretesting process provides insights to the challenge ahead such as poor response rate and tedious data analysis procedures. This enables informed preparation to be made before the actual full-scale data collection process take place.

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