Mediator effect of statistical process control between Total Quality Management (TQM) and business performance in Malaysian Automotive Industry

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Abstract. In today’s highly competitive market, Total Quality Management (TQM) is vital management tool in ensuring a company can succeed in their business. In order to survive in the global market with intense competition amongst regions and enterprises, the adoption of tools and techniques are essential in improving business performance. There are consistent results between TQM and business performance. However, only few previous studies have examined the mediator effect namely statistical process control (SPC) between TQM and business performance. A mediator is a third variable that changes the association between an independent variable and an outcome variable. This study present research proposed a TQM performance model with mediator effect of SPC with structural equation modelling, which is a more comprehensive model for developing countries, specifically for Malaysia. A questionnaire was prepared and sent to 1500 companies from automotive industry and the related vendors in Malaysia, giving a 21.8 per cent rate. Attempts were made at findings significant impact of mediator between TQM practices and business performance showed that SPC is important tools and techniques in TQM implementation. The result concludes that SPC is partial correlation between and TQM and BP with indirect effect (IE) is 0.25 which can be categorised as high moderator effect.

1. Introduction
The concept of total quality management (TQM) has been developed as a result of intense global competition [1, 2]. Firms that manage the international trade in global competition have put emphasis on TQM philosophy, procedures, tools and techniques. Juran [3] defines TQM as philosophy aimed at achieving business excellence through the application of tools and technique, as well as the management of soft aspects, such as human motivation in work. Furthermore, Demirbag et al. [4] defines TQM as a management philosophy aims to contribute continuous improvement in the organization with the participation of all employees to achieve customer satisfaction by producing better, cheaper, faster and safer than competitors. The role of TQM in improving business
performance is broadly agreed in the literature and empirical study[5-8]. TQM helps to manage the
firm to improve the effectiveness and business performance to achieve world class status for the past
two decades [9-11]. However, the study of mediators is neglected and is referred to less frequently in
literature review. The fundamental systems-interactive paradigm of organisational analysis features
the continual stages of input, throughput (processing), and output, which demonstrate the concept of
openness and closeness. Processing is the process of changing from one “look” to another, or one
culture to another [12-14]. In this study, the author defines input as TQM; processing as application
tools and techniques namely SPC; and output as business performance. Thus, one of the objectives of
this study is to empirically analyse the impact of SPC between TQM and business performance.

2. Literature review

Statistical process control (SPC) was pioneered by Walter A. Shewhart in the early 1920’s. Then, W.
Edwards Deming applied SPC methods in the United States during World War II to improve quality in
the military products [15]. Deming also introduced SPC to Japan after the war had ended and he
developed the control chart and the concept of statistical control in the production process [15]. SPC is
used in order to observe a process to ensure the process conforming the specification with a minimum
of recovery [16-18]. In particular, SPC allows sources of variation to be detected and measured, then
amenable for correction. SPC emphasises on early detection and prevention of problems rather than
the correction of problems after they have occurred. SPC eliminates reject product and identifies
bottlenecks, waiting times and other sources of delays within the process [3]. Thus, SPC removes the
need for post-manufacture inspection. However, the application of SPC relies not only on the tools
with which it is applied, but also on how to do correction [19, 20]. Shewhart notes that every process
has variation. Some variation that is controlled and natural to the process is called common sources of
variation. In contrast, variation that is not controlled and not present at all times is called assignable
sources of variation [17]. The assignable sources of variation can be detected, identified, and removed
to ensure the process is stable within a value of limits [18]. In this study, author defines SPC as a
method of statistical techniques for monitoring and controlling the variation in a process to produce
product which meets specification. Rohani et al. [21] conduct study of relationship between SPC and
business performance. SPC is a tool for TQM implementation. However, only few previous studies
have examined the mediators and moderators between TQM and business performance [22-24]. The
inconsistent results between TQM and BP are because the mediators and moderators have been
overlooked in research designs [25-27]. This present research proposed a TQM performance model
with mediator effect of TQM with structural equation modelling, which is a more comprehensive
model for developing countries, specifically for Malaysia.

H1: Relationship between TQM and Business Performance. Most previous studies indicate a
significant relationship between TQM practices and business performance [28-31]. In contrast, other
studies show that TQM does not improve business performance [4, 32]. Other findings show partial
correlation between TQM practices and business performance [4, 9, 33]. Accordingly, the author
proposes that: H1: TQM practices are positively significant and have direct effects on business
performance. H2a: Relationship among TQM and SPC. The relationship between TQM and SPC will
be first reviewed. SPC can assume a stable process, but predictions cannot be made until the process is
fully defined and controlled [34]. TQM provides infrastructure such as top management support,
employee participation, and improvement to implement tools and techniques; thus, TQM should be
implemented before the execution of SPC [3]. Ahmad et al., [16] indicate that TQM practices have
impact on SPC. Thus, TQM practices are positively correlated with SPC. H2a: TQM practices are
positively significance and direct effect on SPC. SPC aims to reduce process variance and
significantly impacts performance improvement, cost savings, and customer satisfaction [35]. Morgan
& Dewhurst [36] indicate that control charts could be adapted to effectively monitor supplier
performance. Rohani et al. [21] conduct a survey on 326 respondents from the Malaysian automotive
industry and find a positive relationship between SPC and business performance. Information
provided by the SPC system enhances the ability of top management to make decisions, in turn
increasing business performance based on SPC data [17, 37, 38]. Thus, SPC increases productivity by reducing waste and improving quality for short- and long-term benefits; this means that SPC practices are positively correlated with business performance. Accordingly, the author proposes that: H2b: SPC practices are positively significant and direct effect on business performance. There are lacks of empirical evidence of SPC as mediator between TQM and business performance in previous work [22]. In this study, SPC acts as mediator between TQM and business performance. Accordingly, the author proposes that: H13: SPC is a mediator between TQM and business performance.

3. Methodology
A seven-point Likert scale was used for the purpose of scoring TQM, SPC and business performance. The questionnaire had been validated by academician and quality experts. It was pilot tested and finalised. A sample of 1500 related to automotive industry companies, was selected from the directories of the Federation of Malaysian Manufacturers (FMM) and the foreign companies directory list in Malaysia. The question has been sent to product quality assurance department (PQA) or quality control manager as the target respondent.

4. Results
Response Rate: Of the 1500 surveys, 327 surveys, which were equivalent to 21.8% response rate, were returned. Of the 327 surveys, 6 surveys were found to have more than 10 percent of unanswered items and 2 surveys were excluded because respondents provided the same responses to all questions in the survey, resulting in an effective sample of 319 usable completed surveys (21.3 percent usable response rate). Convergent validity: All average variance extracted (AVE) values in TQM, BP and SPC constructs were above 0.50 and this evidence supported the convergent validity of the measurement model of TQM [39], as shown in table 1. The results showed that both Cronbach’s alpha and composite reliability for the constructs achieved 0.7, as suggested by Nunally [40] and Hair [39].

| Construct | Item | Loading (L) >0.6 | Cronbach’s alpha α>0.7 | Composite reliability (CR) CR>0.7 | Convergent validity (AVE) AVE>0.5 |
|-----------|------|------------------|------------------------|----------------------------------|----------------------------------|
| TQM       | TQM1 | 0.77             | 0.941                  | 0.938                            | 0.708                            |
|           | TQM2 | 0.82             |                        |                                  |                                  |
|           | TQM3 | 0.79             |                        |                                  |                                  |
|           | TQM4 | 0.82             |                        |                                  |                                  |
|           | TQM5 | 0.72             |                        |                                  |                                  |
|           | TQM6 | 0.83             |                        |                                  |                                  |
|           | TQM7 | 0.83             |                        |                                  |                                  |
|           | TQM8 | 0.82             |                        |                                  |                                  |
|           | TQM9 | 0.81             |                        |                                  |                                  |
|           | TQM10| 0.69             |                        |                                  |                                  |
| SPC       | SPC1 | 0.79             | 0.872                  | 0.872                            | 0.696                            |
|           | SPC2 | 0.89             |                        |                                  |                                  |
|           | SPC4 | 0.84             |                        |                                  |                                  |
| BP        | BP1  | 0.85             | 0.934                  | 0.938                            | 0.715                            |
|           | BP2  | 0.79             |                        |                                  |                                  |
|           | BP3  | 0.88             |                        |                                  |                                  |
|           | BP4  | 0.87             |                        |                                  |                                  |
|           | BP5  | 0.83             |                        |                                  |                                  |
|           | BP6  | 0.81             |                        |                                  |                                  |
Discriminant Validity: The results showed that AVE values were greater than the square of correlation among the constructs, as shown in Table 2. Thus, it can be concluded that discriminant validity was supported.

**Table 2.** Discriminant validity for second order measurement model.

|     | TQM    | SPC    | BP    |
|-----|--------|--------|-------|
| TQM | 0.708  |        |       |
| SPC | 0.569  | 0.696  |       |
| BP  | 0.599  | 0.598  | 0.715 |

Structural equation modeling (SEM): Same procedure of testing for mediator was conducted as Hypothesis H12. SPC as the mediator variable was included into the model, as shown in Figure 1. The result showed that the relationship between TQM and BP was reduced from $r_c=0.81$ (CR=13.177, $p<0.01$) to 0.55 (CR=6.531, $p<0.01$), but still significant, as shown in Table 3. The result also showed that TQM had a significant and direct effect on SPC with $r_c=0.81$ (CR=13.967, $p<0.01$), and SPC also had a significant and direct effect on BP with $r_c=0.31$ (CR=3.748, $p<0.01$). The goodness-of-fit indices for the structural model ($\chi^2$/df=2.357, GFI=0.930, AGFI=0.905, TLI=0.951, CFI=964, and RMSEA=0.065) were well within the generally accepted limits, indicating a good fit to the data. Thus, it can be concluded that SPC partially mediated the relationship between TQM and BP.

![Figure 1. Mediator testing for SPC between TQM and BP.](image-url)
Table 3. Mediators testing result for SPC between TQM and BP.

| No. | Hypotheses | Links in the model | Standardised Estimate (rc) | CR | p-value | Result | Remark |
|-----|------------|--------------------|---------------------------|----|---------|--------|--------|
| 1.  | H11        | TQM → BP           | 0.81                      | 13.177* | 0.000   | Supported | Without SPC |
| 2.  | H11        | TQM → BP           | 0.55                      | 6.531** | 0.000   | Supported | With SPC |
|     | H13a       | TQM → SPC          | 0.81                      | 13.967* | 0.000   | Supported | With SPC |
|     | H13b       | SPC → BP           | 0.31                      | 3.748** | 0.000   | Supported | With SPC |

H13: SPC partially mediates the relationship between TQM and business performance.

Note: *p<0.05; **p<0.01 (one-tailed test)

Table 4. Direct effect and indirect effect for SPC as mediator.

| No. | Effect          | Links in the model | Standardised Estimate (rc) | Result | Remark |
|-----|-----------------|--------------------|---------------------------|--------|--------|
| 1.  | Direct Effect   | TQM → BP           | 0.55                      | Supported |
| 2.  | Indirect Effect | TQM → SPC → BP     | 0.25***                   | Supported | High Effect |
|     | Total effect    | TQM → SPC → BP     | 0.80                      |         |        |

Note: *IE>0.01 (Low); **IE>0.09 (Moderate); ***IE>0.250 (High)

Table 3 shows that the standard indirect effect (IE) of TQM to BP was 0.254, which can be categorised as a high effect of mediation [41]. However, table 4 shows the direct effect and indirect effect for SPC as mediator.

5. Discussion

It was expected that SPC was a mediator between TQM and business performance. According to Baron & Kenny (1986), mediator approach research focuses to identify mechanism as a process between TQM and business performance, besides direct impact of TQM towards performance. Mediator functions to explain “how” or “why” the relationship happened between TQM and business performance [26, 27]. The structural relationships in the structural models were used to test the mediating effect. The results showed that SPC mediated the relationship between TQM and business performance in automotive industries in Malaysia. Thus, SPC can explain the relationship between TQM and business performance, i.e., how to achieve business performance through implementing TQM. However, the mediator test showed partial mediation, explaining that the tool or technique alone did not completely explain the relationship between TQM and business performance [42]. The reason was that there were various tools and techniques that contributed to the business performance.

The results proved that SPC was a mediator between TQM and business performance. This finding is supported by Morgan & Dewhurst [36], Rohani et al., [21], Ahmad et al.,[16], Rahman et al., [43], and Taj & Morosan [35]. According to Rahman et al., [43], SPC is a useful tool to improve quality process, to timely detect abnormality, to check critical parameters, to reduce variations, and to maintain the stability of process. Rohani et al., [21] explored the relationships between SPC and performance from 326 companies in Malaysian automotive industry by using SEM and the result was significant. Many researchers view SPC as a monitoring tool to ensure that the output of a process conforms to the intended design [21, 36]. However, SPC also can be applied in outside production process to effectively improve supplier’s delivery performance to the buyers [36]. The study indicates that SPC approach is effective in monitoring supplier performance through establishing achievable performance targets and meaningful data.
6. Conclusion and future research
The main objectives of this study are to examine the impact of SPC between TQM and business performance. The result concludes that SPC is partial correlation between and TQM and BP with indirect effect (IE) is 0.25 which can be categorised as high moderator effect. It has proved that the impact of SPC based on system theory.

The structural model gave an $r^2=71.0\%$, which means that 71.0% of business performance variance was accounted by TQM and SPC, leaving 29.0% was accounted by unexplained factors that should be explored in future studies. It may include other tools and techniques such as Total Productive Maintenance (TPM), lean production and ISO 9001 that should thus be examined. There may be other critical factors that influence the automotive industries to be included and considered in TQM and business performance.

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