Understanding barriers and motivations in solid waste management from Malaysian industries: a comparative analysis

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Abstract
The objective of this study is to explore the similarities and differences in the barriers and motivations between the plastic and resins and food and beverages industries as these two industries are the major contributors of solid waste in Malaysia. Prior studies are lacking with regard to explaining the barriers and motivations in solid waste management from the Malaysian context. This study is focused on 10 firms from the plastics and resins industry and 9 from the food and beverages industry in Malaysia. Through Rasch measurement theory, the results indicate that the barriers of lack of skills and qualifications and lack of closed-loop control and the motivations of cost savings and a business model are performed differently. The findings further confirm that the lack of skills and qualifications is a more difficult barrier to overcome than the lack of closed-loop control, while the motivation factor of a business model is more difficult to achieve than cost savings. In terms of practical contribution, this study provides results that can help policy makers in Malaysia to close the gaps present regarding the adoption of solid waste management practices and to devise appropriate incentives. The study also supports managers of companies in regard to working on the most pressing hindering and promoting factors in the field of solid waste management.

Keywords Barriers and motivations factors · Solid waste management · Rasch measurement theory · Closed-loop control · Rasch rating scale model

Introduction
The management of solid waste is a global problem, but it is an even greater concern in developing and emerging countries. Overall, the topic of solid waste in emerging countries emerges from industrialization and modernization (Moh and Manaf 2020). In terms of emerging countries in Asia, the management of solid waste materials requires immediate attention in Malaysia, South Korea, and China, which have been identified as emerging industrialized countries (Bhakta et al. 2020). Malaysia is an emerging economy and has active participation from both the plastic and resins (P&R) and food and beverages (F&B) industries. The P&R industry is mostly business to business, whereas the F&B industry is largely business to consumer. For the same reason, the competition in the P&R industry is moderate, whereas competition is intense in the F&B industry. The main players in

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the P&R industry are plastic manufacturers; in F&B, the share is taken primarily by restaurants and cafes. Moreover, small and medium enterprises are more prevalent in the F&B industry in Malaysia than in the P&R industry. Meanwhile, the generation of solid wastes comprises a huge volume. Industry solid waste management (SWM) challenges such as motivation and barriers to sustainable efforts are largely discussed to capture a holistic and in-depth understanding of phenomena and provide better guidance for the industry (Abdul-Hamid et al. 2020; Ahangar et al. 2021; Mondal and Giri 2021). Following this line of argument, two important industries, P&R and F&B, were studied for the following compelling reasons, which are related to the fact that P&R and F&B are among the major contributors to solid waste (Ncube et al. 2021). These industries are commonly the largest industries in emerging economy countries (Simon et al. 2018). The majority of the solid waste in industrial waste is nonrecyclable, and thus requires more sustainable management (Veleva and Bodkin 2017). Increasing solid waste has been a major challenge, especially in emerging economies (Chen et al. 2021). Critical factors such as growing populations, the inadequate enforcement of waste policies, general public attitudes, and economic burdens have daunting the efforts of SWM (Badgie et al. 2012; Negash et al. 2021). This situation calls for the urgent adoption of adequate and better waste management techniques to avoid adverse consequences on the environment (Bui et al. 2020; Chen et al. 2021; Negash et al. 2021). Managing sustainable SWM requires a strategic approach that focuses on the root cause of and the major contributors to solid waste. This study argues that understanding barriers to and motivations for engaging in SWM can improve such practices in Malaysia.

In particular, the generation of P&R waste, particularly in the consumption of single-use plastics and resins, results in a multitude of challenges for emerging countries’ waste management systems. The mismanagement of P&R wastes causes risks to both public health and the overall ecosystem (Chen et al. 2021). Local issues, such as increasing population and urbanization and waste management problems, are increasing (Horodytska and Cabanes 2019). Emerging economy countries have been known as “dump places” or as major importers of plastic waste from more developed countries. P&R waste further threatens coral reefs and marine ecosystems, which impacts adjacent industries such as agriculture. Therefore, the need for the recycling, recovery, and management of P&R waste is of paramount importance, and the P&R industry has a shared responsibility with other industries (Pham Phu et al. 2018). Similarly, food waste is more concerning for emerging economies due to minimal resources and the absence of strict regulations (Ncube et al. 2021). The adverse impacts from the F&B industry on the environment often attract media attention, but corrective action is often lacking (Aarnio and Anne 2008). This is exemplified by the continuous pressure from the media demanding that the government introduce and regulate sustainable programs and approaches for companies in the F&B industry (Ncube et al. 2021). This study aims to understand the shortcomings of SWM barriers and motivation factors in related practices.

Determining how the P&R and F&B industries perform in SWM in terms of barriers and motivations is a pressing and relevant topic for the following two reasons. First, these two industries contribute the majority of solid waste, and their approach to addressing barriers and reinforcing motivations can provide guidance on dealing with the issue of SWM. Second, there are commonalities between these two industries. For example, during the present COVID-19 pandemic and extended lockdown situation in different areas, food takeaway options have significantly increased. Customers who preferred a dine-in meal at their favorite restaurant had no choice but to place food delivery orders (Bhakta et al. 2020; Carroll and Conboy 2020). These food deliveries were usually contained in single-use food packaging plastics. Consumption therefore leads to an increase in both plastic waste and food waste, which is an overlapping area between the two industries (Duarte et al. 2020). There is a need to study these two industries and clarify the strategic points in SWM.

Even within the specialist literature in this area, empirical evidence comparing the P&R and F&B industries is relatively scarce (Chen et al. 2021; Zorpas et al. 2021). The majority of previous literature focuses on barriers and motivations for SWM, examining either a broad perspective covering multiple industries (Azevedo et al. 2019; Fedotkina et al. 2019; Bhakta et al. 2020) or covering only one specific industry (Chen et al. 2021; Horodytska and Cabanes 2019; Zorpas et al. 2021). In terms of the plastics industry, past studies have focused largely on recycling (Chen et al. 2021), packaging (Ncube et al. 2021), and reuse (Horodytska and Cabanes 2019). In terms of the food industry, the empirical focus of past research has been on using new technologies such as blockchain (Ali et al. 2021) and dealing with household and commercial food waste (Aarnio and Anne 2008).

In comparing the different performances, barriers and motivations for SWM between the P&R and F&B industries, there are two main objectives of the current study. (1) Barriers are important to understand as they need to be overcome in order to achieve the potential of companies with regard to SWM. Likewise, motivations are important as they reinforce and encourage companies to prioritize SWM in their business model and operations. (2) The Rasch measurement theory (RMT) has been used to rigorously compare and contrast the differences between barriers and motivations from these two industries in terms of what works in a certain industry and what does not work equally well in each industry. Achieving these two objectives will contribute to dynamic
capabilities theory (Arend and Bromiley 2009) as firms in both the P&R and F&B industries will be encouraged to find and develop new competencies based on overcoming their barriers to the adoption of SWM. Likewise, the results regarding motivating factors in the P&R and F&B industries will signify the importance of competencies that have already been mastered by the firms in the SWM domain. This study will also extend the theory by reinforcing the dimensions or factors that can lead to the expansion of the resource base of firms in the two industries of P&R and F&B, which in turn improve the capability matrix for firms working on SWM practices.

This research studies 19 companies across Malaysia, namely, 10 from the P&R industry and 9 from the F&B industry. To achieve the objectives and to close the research gap, this study is structured as follows. First, based on the literature, a theoretical framework is presented. Second, the research method of Rasch is described. Third, the results are presented in terms of both barriers and motivations. Finally, the study concludes with a discussion of the results with their implications and the study limitations.

Theoretical background

Solid waste management barriers

In the literature, various barriers to the adoption of SWM have been studied and empirically analyzed. The most common ones are high investment cost (Yukalang et al. 2017; Ranta et al. 2018), absence of governmental pressure (Veleva and Bodkin 2017), lack of skills and qualifications (Yukalang et al. 2017; Ranta et al. 2018), and lack of closed-loop control (Veleva and Bodkin 2017). Juxtapose, Ritzén and Sandström (2017) emphasized the importance of a lack of technological infrastructure as a profound barrier, whereas Veleva and Bodkin (2017) found a lack of capabilities to reconfigure production patterns to be the most challenging barrier. The main research gap is that the majority of previous literature focuses on barriers from a wide perspective, comparing all industries together (Azevedo et al. 2019; Fedotkina et al. 2019; Bhakta et al. 2020), whereas the present study aims to take a narrow view of barriers in terms of two industries: P&R and F&B.

The P&R industry consists of companies chiefly engaged in manufacturing various plastics and resins (solid convertible into polymers) for sale to other industries that create plastic sheets, rods, films, and other products. The F&B industry comprises restaurants, cafeterias, food manufacturing operations, catering businesses, and food transportation service providers ranging from packaging to preparing, transporting, and serving food or beverages. Both of these industries have a unique set of barriers to adopting SWM practices. As per dynamic capabilities theory, organizations adopt, implement, and change their internal and external firm-specific competencies into new competencies based on the environment (Arend and Bromiley 2009; Teece and Pisano 1994). In this regard, the barriers faced by firms in terms of SWM can be overcome to develop new competencies for firms.

There are a variety of barriers faced by firms in the P&R industry, beginning with resources that mainly include skilled manpower and the right equipment (Tsai et al. 2020). The lack of these factors is particularly crucial for the P&R industry as a manufacturing industry. Furthermore, the design of an intelligent system for controlling the composition of solid waste is needed (Ali et al. 2021; Negash et al. 2021). There is a need to comprehend the urbanization trend in the country to foresee the inference of urban growth on plastic waste generation. In other words, precise and reliable data about a community’s plastic waste profile are necessary for a successful waste management system. Overall, emerging economies are still not fully capable of administering SWM facilities due to their resourcefulness and technical capabilities in the plastics and resins industry (Ahangar et al. 2021; Li 2018; Mondal and Giri 2021). Therefore, return on investment in SWM is low in this industry and is a major barrier.

Likewise, there are multiple barriers in the F&B industry. SWM for F&B services has a cost, and due to its specific perishability nature, expenditures are usually not recovered. In the best of cases, citizens are considered co-responsible together with companies and the government (Abarca et al. 2013). Communication among stakeholders is also necessary to obtain a performing food waste management system, which is seen as a barrier. Recycling and waste control at the source of food waste are also largely missing (Ali et al. 2021; Negash et al. 2021). Moreover, the attitudes of people towards waste management are a barrier for the F&B industry (Badgie et al. 2012). Another important challenge to address is the influence of education and awareness, which is a prime barrier for SWM (Dinie et al. 2013). In most emerging countries, environmental awareness among the public is not encouraging (Milea 2009). For example, the Malaysian government in 1988 introduced the Action Plan for Beautiful and Clean (ABC) Malaysia followed by a recycling campaign in the following years. However, the campaigns have not resulted in major positive results due to little participation from the public. Similarly, recycling bins mostly had contents that were found to be nonrecyclable (Horodytska and Cabanes 2019; Pham Phu et al. 2018).

SWM barriers are important to study and analyze because they either prevent or make it difficult for firms to adopt SWM practices (Bhakta et al. 2020). It is also important to understand that not all barriers have equal weight (Ali et al. 2021; Negash et al. 2021) or require the same time and effort.
have been presented in the literature, which has placed even more focus on studying the barriers to SWM and the level of difficulty for these two industries. For example, companies’ attitudes towards SWM is a challenge when environmental issues are not a high priority (Badgie et al. 2012); however, the study by Dinie et al. (2013) found out that concern for environment is well established. Likewise, while the lack of enforcement of solid waste legislation is a barrier to proper documentation in emerging economies like Malaysia (Moh and Manaf 2020), the study by Mondal and Giri (2021) reconfirmed that government policies in Malaysia regarding SWM have been adequately aligned.

Firms studying the various barriers of SWM can better analyze their own strengths and weaknesses and plan a roadmap to overcome the barriers while keeping their business plan and sustainability as the terminal objectives (Joshi and Ahmed 2016). In particular, in the present pandemic (COVID-19), firms are finding it difficult to survive, and overcoming the barriers to SWM is even more challenging (Aarnio and Anne 2008). Hence, it is important to understand the intricacies, difficulties, and implications of various barriers to SWM, which in turn will help firms move towards the adoption of SWM practices.

**Solid waste management motivations**

Drawing from the literature, relatively few motivational factors have been studied in the area of SWM practices. Aparcana (2016) considered cost savings the main motivation, whereas Masrom et al. (2018) valued motivation from competitors and revenue pressure, respectively, for the adoption of SWM practices. The research gap that remains highlights that existing studies largely focus on motivations from all industries combined (Fedotkina et al. 2019; Bhakta et al. 2020). Therefore, the present study has a sharp focus on motivations in terms of two industries: P&R and F&B. Dynamic capabilities theory states that organizations purposefully create, extend and modify their resource base (Arend and Bromley 2009; Teece and Pisano 1994). Therefore, the motivations faced by firms to adopt SWM practices can be identified to improve the resource base of the firm.

In the P&R industry, there are multiple opportunities in the area of solid waste that can motivate companies to adopt practices and processes towards SWM. The first motivation is pressure from the public, which can also be categorized as customer demands (Alhumoud and Al-Kandari 2008). In the product area, when consumers are conscious, they impose pressure on product companies to improve their commitment to SWM (Pariatamby and Solutions, 2014; Taylor et al. 2015). Furthermore, in some countries, there exists a concept of extended producer responsibility (EPR) that holds companies responsible for their product even after its useful life (Gu et al. 2018). Benefits of adopting SWM practices can be in the area of cost reduction as well as process optimization (Gaeta et al. 2021). The opportunity overall is to improve the sustainability of companies and their products, which is a win–win for producers, consumers, and governments equally. In terms of economics, opportunities also exist for businesses in terms of tax credits and allowances, which encourage solid waste minimization, cleaner production, and recycling, particularly in the business-to-business (B2B) setting of the P&R industry (Moh and Manaf 2020; Wee and Seow 2014).

In the F&B industry, the same public pressure applies to companies and the government to improve SWM. However, in this industry, the public is both the motivator and the executor as they not only put pressure on companies but also have to demonstrate through their societal actions that they value preventing F&B waste. With the increasing awareness of food waste and its drastic effects, small and medium enterprises in the F&B industry feel empowered to recycle and reuse. Environmental education passed on through government public policy and private associations has also motivated the prioritization of the topic of food waste. Likewise, it is important to note that there are various small and medium companies that are not able to bear the elevated costs of high-quality waste management, which otherwise is an opportunity for national and provincial legislation on this important topic of food and beverage waste (Azevedo et al. 2019).

Moreover, there is a disconnect on certain occasions in terms of motivations for SWM. For instance, environmental stewardship is a great opportunity for companies (Yukalang et al. 2017), whereas the authors of Masrom et al. (2018) are of the view that adherence to international standards is not the main attraction for firms to adopt SWM practices. Similarly, firms with the potential to make footprints with regard to SWM are more profitable in Malaysia (Mondal and Giri 2021), whereas the studies by Fedotkina et al. (2019) and Bhakta et al. (2020) implied that there is business continuity risk assigned with companies putting SWM as their radar with regard to business performance.

Overall, it is important to study the various factors that motivate firms to adopt SWM as a major push is needed on that front, especially because the majority of firms still have not taken the first step towards effective SWM (Boyle 2000; Yukalang et al. 2017). It is also important in terms of positive reinforcement to attract and empower firms to drive initiatives around SWM and to provide them with incentives for doing so. SWM is a multidimensional issue (Abarca et al. 2013) that includes environmental, social, cultural, legal, institutional, economic, and technological factors (Moh and Manaf 2020). Businesses aim at increased efficiency and reduced cost to be sustainable. Therefore, in the drive to adopt SWM practices, it is important to study the motivations for SWM and how it can assist companies in efficiency and cost.
Method

Research setting: Malaysia as an emerging economy

Malaysia, as an emerging country, encounters issues in terms of its technology, workforce, and infrastructure, which are inadequate to cope with the ever-increasing momentum of waste generation (Badgie et al. 2012). Solid waste generation in Malaysia has recently approached a critical point, especially in terms of volume and composition. Statistics from Malaysian Investment Development Authority show that the average quantity of solid waste at the country level exceeds 38,000 tons per day. What is more worrying is the fact that these numbers are expected to increased significantly. In terms of the industry split, Bloomberg reported that the market size of the P&R industry in Malaysia is over US$3,200 million, whereas the market size of F&B is over US$6 billion. These market sizes reaffirm that both the industries studied in this study are of paramount importance to Malaysia and serve as interesting cases for regional countries. Prior management of solid waste demanded less effort as the waste was generated at a manageable level, but now it is alarming, particularly in terms of plastic disposal and food leftovers (Chen et al. 2021). The government of Malaysia implemented a Strategic Plan 2014–2020 including subjects such as mindset, behavior, and culture, which resulted in an approximately 30% recycling rate in 2020 (Moh and Manaf 2020). However, with the heavy reliance on landfilling in Malaysia, it is unavoidable that there are issues of space limitations (Chen et al. 2021). In short, Malaysia, as an emerging country, has experienced economic growth in recent years that has directly resulted in an increase in solid waste pollution, particularly in terms of plastic and food waste (Ncube et al. 2021; Pham Phu et al. 2018).

Two selection criteria were designed to identify and select respondents for the survey: (a) senior managers with organization-wide understanding and (b) at least 1 year of experience working in the company. In line with these criteria, the respondents who became part of this research study (a) were mostly directors and departmental heads and (b) had a minimum of 3 years of working experience in the current company. Data collection was performed across the different states of Malaysia. As a result, 19 companies were studied according to the research aims of this study, of which 10 were from the P&R industry and 9 were from the F&B industry. Of these 19 companies, most were Malaysian-owned (79%). In terms of company age, the majority of the companies were 11–20 years old (37%), followed by more than 30 years old (26%). Second, in terms of the number of employees in the company, 74% of companies had 250 employees or less. Likewise, in terms of annual sales turnover, the majority of the companies (53%) enjoyed an annual sales turnover of more than 50 million Malaysian ringgits. Details of the sample structure are presented in Table 1.

| Table 1 Description of sample | Number of companies |
|-------------------------------|---------------------|
| **Industry classification**   |                     |
| Plastics and resins           | 10                  |
| F&B                          | 9                   |
| **Ownership**                 |                     |
| Malaysian-owned               | 15                  |
| Non-Malaysian-owned           | 4                   |
| **Company age**               |                     |
| < 5 years                     | 3                   |
| 6–10 years                    | 3                   |
| 11–20 years                   | 7                   |
| 21–30 years                   | 1                   |
| > 30 years                    | 5                   |
| **Employees in the company**  |                     |
| < 100                         | 7                   |
| 101–250                       | 7                   |
| 251–500                       | 1                   |
| 500–1000                      | 1                   |
| > 1000                        | 3                   |
| **Annual sales turnover**     |                     |
| (Malaysian ringgit)           |                     |
| < 300,000                     | 1                   |
| 300,000–15,000,000            | 2                   |
| 15,000,000–50,000,000         | 6                   |
| > 50,000,000                  | 10                  |
| **Total**                     | 19                  |
Andrich (1978) and Wolins et al. (1982) formulated a model for dichotomous items that resulted in the Rasch rating scale model (RRSM). The RRSM allows the definition of the latent variable through polytomous items in ordered categories (Azizan et al. 2020). The Naiperian expression of this model is as follows:

\[
L_n\left(\frac{p_{nij}}{p_{n(i-1)}}\right) = \beta_n - (\delta_i + \tau_j)
\]

where:

- \(p_{nij}\) probability of the observed category \(j\).
- \(p_{(n(i-1))}\) probability of the observed category \((j-1)\).
- \(\beta_n\) measurement of the ability of subject \(n\).
- \(\delta_i\) measurement of difficulty of item \(I\).
- \(\tau_j\) differential of difficulty of observed category \(j\) in relation to the previous \((j-1)\).

The invariance feature is inherent to the structure of the Rasch models, which establishes whether some item in the measurement of the construct performs a different function (Andrich 1978). For this, it is vital to analyze the differential item functioning (DIF) and to identify the presence of bias when a group of subjects with some common feature obtains a significantly different calibration from that of another group in an item’s difficulty (Schauerger and Mair 2020). The RRSM is particularly ideal for measuring latent variables such as barriers and motivations as it is the result of the measurements assessed by respondents from both the P&R and F&B industries. Barrier and motivation items are positioned on a linear continuum, allowing them to be measured according to their ability and difficulty, respectively, from left (less) to right (more). Likewise, the DIF analysis allows identification of the presence of different levels of difficulty and statistical significance in the P&R and F&B differentiated industries.

**Measurement scale and fit diagnosis**

In this study, there are two constructs: barriers and motivations. The items for the construct “barriers” were measured through 24 factors that have been identified in the past literature and empirical studies as elements that accelerate the progress of SWM (Janmaimool 2017; Fan et al. 2018; Masrom et al. 2018). The scale to measure the ratings was adapted to a 5-point Likert scale with the following levels: 1 (very little extent), 2 (little extent), 3 (some extent), 4 (great extent), and 5 (very great extent). The software Winsteps version 4.4.7 was used for data handling. Table 2 shows the main specifications of this study. The measurement items for both barriers and motivations are listed in Table 3.

In the diagnosis of the fit, the need to recategorize the measurement scale is not explicitly observed. Following previous recommendations (Linacre 2009), we chose to establish a structure with 5 categories. The estimates of Andrich threshold parameters (−2.00, −0.68, 0.72, 1.95) guarantee the absence of disorders in the levels of difficulty of the items, confirming the effectiveness of the structure of categories. Furthermore, the latent trait barriers and motivations have only one dimension, and the items considered for their definition in the domain of SWM reflect only one reality. This operational requirement of the RRSM was checked with three types of analysis. The first is the principal component analysis of Rasch residuals (PCAR), in which the values of the indicators obtained (variance explained 42.4%, unexplained variance in first contrast 5.53%) allows us to discard the presence of multidimensionality tensions (Linacre 2009).

Second, the positive point-measure (PTM) correlation sign confirms the adequacy of the measurements. As seen in Table 4 and Table 5, the PTM of all items is positive except for motivation item number 2 (green/sustainability credentials), which had −0.18 PTM, which resulted in the deletion of this item. Finally, the reliability and validity analysis was assessed by using Rasch estimators of measurement separation for subjects and items. As the values were above 0.70, the Rasch standard levels were confirmed, confirming the reliability and validity of the measurement.

Regarding the individual validity analysis, the outfit mean square of residuals (MNSQ) for three items was above the recommended levels (Wright and Linacre 1994): barrier “lack of organizational and process changes,” barrier “high investment,” and barrier “absence of consumer demand”, their Outfit MNSQs were −2.73, −2.83, and 2.50, respectively, as shown in Table 4. These three barrier items were checked individually, and no distortions were found; hence, the items were...

### Table 2  Technical specifications

| Industries | P&R and F&B |
|------------|-------------|
| Context    | Malaysia    |
| Type of information | Primary |
| Data collection method | Survey |
| Time scope | May 2021—August 2021 |
| Sample size | 19 Companies (10 P&R, 9 F&B) |
| Data handling | Rasch Winsteps software, version 4.4.7 |
retained. Overall, the diagnosis allows confirmation of the fit of data to Rasch measurement theory. Hence, the measures obtained adopt the properties of the model.

**Results**

To answer the main research question of this study, the RRSM of the DIF analysis (Linacre 2009) was applied to identify whether there were significant differences in both barriers and motivations among the two industry groups. The statistical Welch’s $t$ test of difference in means was used, and the indicators of differential behavior were interpreted (Bond and Fox 2003). The hypothesis of the existence of differences in the items’ differential behavior was accepted when significance was under 0.05. In addition, the differences were considered based on the DIF contrast value: DIF contrast less than 0.43 was considered small, DIF contrast between 0.43 and 0.64 was considered moderate, and DIF contrast greater than 0.64 was considered large (Linacre 2002; Wright and Linacre 1994).

The DIF analysis was conducted in two stages. In the first stage, the two industries, P&R and F&B, were compared in terms of barriers to SWM. Table 6 shows each barrier item with its significance value and DIF contrast.
| No | Items                                                                 | MEASURE | STD ERR | INFIT MNSQ | INFIT ZSTD | OUTFIT MNSQ | OUTFIT ZSTD | PTM |
|----|----------------------------------------------------------------------|---------|---------|------------|------------|-------------|-------------|-----|
| B1 | Lack of knowledge management systems                                 | 0.04    | 0.27    | 0.60       | −1.45      | 0.60        | −1.46       | 0.50 |
| B2 | Absence of governmental pressure                                     | 1.07    | 0.27    | 1.63       | 1.83       | 1.62        | 1.79        | 0.31 |
| B3 | Lack of evidence of profitability                                    | 0.26    | 0.27    | 1.08       | 0.37       | 1.07        | 0.34        | 0.58 |
| B4 | Poor company SWM operations vision/mission                           | 0.26    | 0.27    | 0.84       | −0.45      | 0.84        | −0.46       | 0.58 |
| B5 | Lack of skills and qualifications                                    | −0.92   | 0.30    | 1.22       | 0.78       | 1.52        | 1.60        | 0.24 |
| B6 | Difficulty regulating framework                                      | −0.26   | 0.28    | 1.05       | 0.26       | 1.05        | 0.26        | 0.23 |
| B7 | Absence of regulatory framework                                      | −0.26   | 0.28    | 1.04       | 0.23       | 1.02        | 0.15        | 0.27 |
| B8 | Absence of consumer demand                                           | 1.07    | 0.27    | 1.94       | 2.51       | 1.93        | 2.50        | 0.41 |
| B9 | Perception of high business risk                                     | −0.19   | 0.28    | 1.00       | 0.09       | 1.00        | 0.11        | 0.32 |
| B10| Dominant position of key market players                              | 0.11    | 0.27    | 1.23       | 0.80       | 1.22        | 0.78        | 0.15 |
| B11| Lack of capabilities to reconfiguring production pattern              | −0.03   | 0.27    | 0.62       | −1.35      | 0.62        | −1.36       | 0.49 |
| B12| Lack of closed-loop control                                          | 0.19    | 0.27    | 0.97       | −0.01      | 0.97        | 0.02        | 0.08 |
| B13| Lack of knowledge base                                                | −0.50   | 0.28    | 0.56       | −1.68      | 0.57        | −1.65       | 0.71 |
| B14| Lack of organizational and process changes                            | −0.19   | 0.28    | 0.37       | −2.70      | 0.37        | −2.73       | 0.24 |
| B15| Lack of process design                                                | −0.19   | 0.28    | 0.91       | −0.21      | 0.89        | −0.30       | 0.03 |
| B16| Unstable connectivity among companies                                 | 0.19    | 0.27    | 1.13       | 0.50       | 1.12        | 0.49        | 0.25 |
| B17| Lack of understanding of SWM implications                              | 0.34    | 0.27    | 0.77       | −0.71      | 0.77        | −0.70       | 0.63 |
| B18| High investment                                                       | −1.10   | 0.31    | 0.32       | −3.02      | 0.35        | −2.83       | 0.48 |
| B19| Difficulty recovering materials for recycling                         | −0.66   | 0.29    | 0.85       | −0.43      | 0.81        | −0.57       | 0.13 |
| B20| Low management support and dedication                                 | 1.00    | 0.27    | 0.58       | −1.51      | 0.57        | −1.54       | 0.22 |
| B21| Lack of experience leader                                             | −0.03   | 0.27    | 1.24       | 0.85       | 1.25        | 0.87        | 0.49 |
| B22| Shareholder pressure promotes linear thinking                         | 1.00    | 0.27    | 0.84       | −0.46      | 0.83        | −0.47       | 0.01 |
| B23| Lack of technological infrastructure                                   | −0.50   | 0.28    | 0.76       | −0.79      | 0.74        | −0.87       | 0.40 |
| B24| Lack of compatibility                                                 | 0.19    | 0.27    | 1.18       | 0.67       | 1.18        | 0.66        | 0.64 |
obtained confirm the existence of differences between these two industry groups for two barrier items, namely, B5, “lack of skills and qualification,” and B12, “lack of closed-loop control.” The first interindustry difference of B5, “lack of skills and qualification,” has a probability of 0.0216 (significant as $P < 0.05$) and a DIF contrast of 1.74 (categorized as a large difference). Based on the positive direction of comparison from F&B to P&R, the first finding of the study reveals that barrier B5, “lack of skills and qualification,” is a difficult barrier to overcome in the F&B industry compared to the P&R industry with regard to the adoption of SWM practices. The second interindustry difference of B12, “lack of closed-loop control,” has a probability of 0.0322 (significant as $P < 0.05$) and a DIF contrast of 1.29 (also categorized as a large difference). Based on the positive direction of comparison from P&R to F&B, the second finding of the study reveals that barrier B12, “lack of closed-loop control,” is a difficult barrier to overcome in the P&R industry compared to the F&B industry with regard to the adoption of SWM practices.

The two industries, P&R and F&B, were compared in terms of motivations for SWM. Table 7 shows each motivation item with its significance value and DIF contrast. Subsequently, it needs to be distinctly determined whether there are significant differences in the item responses between the respondents from the P&R and F&B industries. The results obtained confirm the existence of differences between these two industry groups for two motivation items, namely, M1, “achieve cost savings,” and M6, “moving towards SWM model.” The third interindustry difference of M1, “achieve cost savings,” has a probability of 0.0195 (significant as $P < 0.05$) and a DIF contrast of 1.43 (categorized as a large difference). Based on the positive direction of comparison from P&R to F&B, the fourth finding of the study reveals that the motivation factor M6, “moving towards SWM model,” is a difficult factor to achieve in the P&R industry compared to the F&B industry with regard to the adoption of SWM practices.

### Discussion

The present study contributes to the literature on the comparison of the SWM performance of the P&R industry with that of the F&B industry using RMT to study their barriers and motivations. This study has resulted in additional empirical evidence regarding the differences in the adoption of SWM practices between these two industries, resulting in a theoretical contribution.

Specifically, this study’s results show four main findings. First, barrier B5, “lack of skills and qualification,” is a difficult barrier to overcome in the F&B industry compared to the P&R industry due to formal and informal training and development structural differences between the two industries (Abarca et al. 2013; Ma et al. 2017). Second, barrier B12, “lack of closed-loop control,” is a difficult barrier to overcome in the P&R industry compared to the F&B industry due to varying complexity between the industries (Manavalan and Jayakrishna 2018). Third, the motivation factor M1, “cost savings,” is a difficult factor to achieve in the P&R industry compared to the F&B industry, taking inference from the scale of organizations in the two industries (Chen et al. 2021; Lingard et al. 2000). Fourth, the motivation factor M6, “moving towards SWM model,” is a difficult factor to achieve in the P&R industry compared to the F&B industry due to the consumption versus the manufacturing nature of organizations in the two industries (Fan et al. 2018; Tsai et al. 2020).

The findings confirm that barrier B5, “lack of skills and qualification,” is significant and performs differently between two industries such that it is a difficult barrier to overcome in the F&B industry compared to the P&R
industry. This finding resonates with the studies by Ma et al. (2017) and Abarca et al. (2013). The major reason for this is the structure and organization of training and development. In the P&R industry, firms are mostly medium- to large-sized organizations that have a formal training and development department that ensures that upskilling and reskilling are periodically planned and executed. On the other hand, the F&B industry is mostly driven by small and medium-sized organizations, which mostly have an informal training and development structure. Therefore, the barrier “lack of skills and qualification” is easy to deal with in the P&R industry but relatively difficult to deal with in the F&B industry. However, this result is contrary to the study by Luiz et al. (2016), where technology takes preference over training.

Barrier B12, “lack of closed-loop control,” is significant and performs differently between the two industries such that it is a difficult barrier to overcome in the P&R industry compared to the F&B industry. Closed-loop control is a control system based on monitoring feedback through which feedback identifies deviation and, as a result, controls the action (Manavalan and Jayakrishna 2018). This control system thrives on feedback to determine the outcome and to minimize deviations. In terms of SWM, this finding echoes the studies by Negash et al. (2021) and Manaf et al. (2009). This can be largely explained by the fact that in the P&R industry, processes are complex due to the

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\begin{array}{cccccc}
\text{No} & \text{Industry groups} & \text{DIF contrast} & t & \text{Probability} & \text{Items} \\
B1 & P&R & F&B & 1.10 & 1.97 & 0.0663 & \text{Lack of knowledge management systems} \\
B2 & P&R & F&B & 0.29 & 0.54 & 0.5991 & \text{Absence of governmental pressure} \\
B3 & F&B & P&R & 0.35 & 0.65 & 0.5250 & \text{Lack of evidence of profitability} \\
B4 & F&B & P&R & 0.96 & 1.73 & 0.1024 & \text{Poor company SWM operations vision/mission} \\
B5 & F&B & P&R & 1.74 & 2.56 & 0.0216 & \text{Lack of skills and qualifications} \\
B6 & F&B & P&R & 0.48 & 0.85 & 0.4058 & \text{Lack of regulatory framework} \\
B7 & F&B & P&R & 0.48 & 0.85 & 0.4058 & \text{Difficulty accessing suitable financing} \\
B8 & P&R & F&B & 0.89 & 1.63 & 0.1228 & \text{Absence of consumer demand} \\
B9 & F&B & P&R & 0.32 & 0.58 & 0.5675 & \text{Perception of high business risk} \\
B10 & P&R & F&B & 0.25 & 0.47 & 0.6469 & \text{Dominant position of key market players} \\
B11 & P&R & F&B & 0.27 & 0.50 & 0.6256 & \text{Lack of capabilities to reconfigure production pattern} \\
B12 & P&R & F&B & 1.29 & 2.35 & 0.0322 & \text{Lack of closed-loop control} \\
B13 & F&B & P&R & 0.32 & 0.56 & 0.5833 & \text{Lack of knowledge base} \\
B14 & F&B & P&R & 0.00 & 0.00 & 1.000 & \text{Lack of organizational and process changes} \\
B15 & P&R & F&B & 0.59 & 1.07 & 0.2992 & \text{Lack of process design} \\
B16 & P&R & F&B & 0.40 & 0.73 & 0.4773 & \text{Unstable connectivity among companies} \\
B17 & P&R & F&B & 0.08 & 0.15 & 0.8804 & \text{Lack of understanding on SWM implications} \\
B18 & F&B & P&R & 0.57 & 0.90 & 0.3822 & \text{High investment} \\
B19 & F&B & P&R & 0.00 & 0.00 & 1.000 & \text{Difficulty recovering materials for recycling} \\
B20 & P&R & F&B & 0.45 & 0.83 & 0.4194 & \text{Low management support and dedication} \\
B21 & F&B & P&R & 0.95 & 1.69 & 0.1098 & \text{Lack of experience leader} \\
B22 & F&B & P&R & 0.14 & 0.26 & 0.7945 & \text{Shareholder pressure promotes linear thinking} \\
B23 & F&B & P&R & 0.65 & 1.13 & 0.2767 & \text{Lack of technological infrastructure} \\
B24 & F&B & P&R & 1.10 & 1.99 & 0.0642 & \text{Lack of compatibility} \\
\end{array}
\]

Table 6: DIF of P&R and F&B industry: barriers

Industry, This finding resonates with the studies by Ma et al. (2017) and Abarca et al. (2013). The major reason for this is the structure and organization of training and development. In the P&R industry, firms are mostly medium- to large-sized organizations that have a formal training and development department that ensures that upskilling and reskilling are periodically planned and executed. On the other hand, the F&B industry is mostly driven by small and medium-sized organizations, which mostly have an informal training and development structure. Therefore, the barrier “lack of skills and qualification” is easy to deal with in the P&R industry but relatively difficult to deal with in the F&B industry. However, this result is contrary to the study by Luiz et al. (2016), where technology takes preference over training.

Barrier B12, “lack of closed-loop control,” is significant and performs differently between the two industries such that it is a difficult barrier to overcome in the P&R industry compared to the F&B industry. Closed-loop control is a control system based on monitoring feedback through which feedback identifies deviation and, as a result, controls the action (Manavalan and Jayakrishna 2018). This control system thrives on feedback to determine the outcome and to minimize deviations. In terms of SWM, this finding echoes the studies by Negash et al. (2021) and Manaf et al. (2009). This can be largely explained by the fact that in the P&R industry, processes are complex due to the

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\begin{array}{cccccc}
\text{No} & \text{Industry groups} & \text{DIF contrast} & t & \text{Probability} & \text{Items} \\
M1 & P&R & F&B & 1.43 & 2.60 & 0.0195 & \text{Cost savings} \\
M2 & P&R & F&B & 1.07 & 1.78 & 0.0949 & \text{Green/sustainability credentials} \\
M3 & F&B & P&R & 0.16 & 0.29 & 0.7778 & \text{Competitors’ actions} \\
M4 & F&B & P&R & 0.54 & 0.99 & 0.3363 & \text{Downward pressure on revenue/profits} \\
M5 & P&R & F&B & 0.41 & 0.65 & 0.5270 & \text{Explicit customer demand/preferences} \\
M6 & P&R & F&B & 1.95 & 3.43 & 0.0034 & \text{Move towards a SWM model} \\
M7 & P&R & F&B & 0.05 & 0.09 & 0.9277 & \text{Scarcity of natural resources} \\
\end{array}
\]

Table 7: DIF of P&R and F&B industry: motivations
size of the organization, whereas F&B industry players, mostly have straightforward and simple processes. Therefore, due to the complexity and size of organizations, it is difficult to overcome the lack of closed-loop control in the P&R industry, which is easier to manage in the F&B industry.

This study confirms that the motivation factor M1 “achieve cost savings” is significant and performs differently between the two industries such that it is a difficult motivation factor to achieve in the P&R industry compared to the F&B industry. The P&R industry consists of entities that are involved in manufacturing various plastics and resins (solid convertible into polymers) for sale to other industries that create plastic products. The setup of companies in this industry is comparable to established companies for which cost savings are an everyday exercise. As they work on cost saving initiatives regularly, cost saving as a motivation is not a dominant factor for this industry. However, the motivation of cost savings is a driving force in dealing with F&B industry players, which comprise small setups such as restaurants, cafeterias, and catering businesses. This finding resonates with the studies by Lingard et al. (2000) and Chen et al. (2021). Therefore, due to the scale of organizations, cost savings are an easy motivation factor to achieve in the F&B industry compared to the P&R industry.

The motivation factor M6 “moving towards SWM model” is significant and performs differently between the two industries such that it is a difficult motivation to achieve in the P&R industry compared to the F&B industry. This finding is in concurrence with the studies by Fan et al. (2018) and Tsai et al. (2020). There is a major contrast between the two studied industries. The F&B industry is largely a consumption-based industry, whereas P&R is predominantly a manufacturing-based industry or, recently, has reoriented itself to be an auxiliary industry (a combination of manufacturing and consumption). Additionally, modern manufacturing is advanced and complex, and adapting or customizing the existing advanced manufacturing models to gain the merits of SWM can be challenging initially (Behzad et al. 2011; Fukuda 2020). Therefore, due to the consumption, manufacturing, and auxiliary concerns of organizations, moving towards a SWM model is an easy motivation factor to achieve in the F&B industry but a difficult motivation factor to achieve in the P&R industry.

All four study findings have a large DIF contrast, implying a large significant difference for each of these four items between the two industries. For a comparative analysis, the calibration for barrier B5 “lack of skills and qualification” (DIF Contrast 1.74) is higher than B12 “lack of closed-loop control” (DIF Contrast 1.29), implying that barrier B5 “lack of skills and qualification” is more difficult to overcome than B12 “lack of closed-loop control.” The calibration for motivation factor M6 “moving towards SWM model” (DIF Contrast 1.95) is higher than M1 “achieve cost savings” (DIF Contrast 1.43), implying that the motivation factor M6 “moving towards SWM mode” is more difficult to achieve than M1 “achieve cost savings.”

This study complements and extends research on the P&R and F&B industries and their barriers and motivations in the following four aspects. First, the categorization of plastics and resins with the F&B industry in the SWM sector according to barriers and motivations has made it possible to reconcile the empirical evidence in this regard, which is lacking. Second, the study identifies differences in terms of skills and qualifications (Luiz et al. 2016), closed-loop control (Horodytska and Cabanes 2019), cost savings (Mona et al. 2016), and business models (Tsai et al. 2020) between the two industries. Third, it supports and extends the findings of Chen et al. (2021), Ncube et al. (2021), and Bhakta et al. (2020). Finally, it introduces a measuring instrument, the RMT, that has not been used before in the comparison of the solid waste sector between the P&R and F&B industries.

Conclusions

In Malaysia, the lack of public conscientiousness in modern lifestyles has resulted in an increasing amount of both waste generation and waste disposal, especially in regard to plastic and food waste. Therefore, awareness contributes significantly to the environmental response with regard to how society perceives the issue and how people direct their behavior in managing solid waste. Adding to socioeconomic factors, the perception of infinite resources with no observable environmental consequences to the public is also a factor in overconsumption, which produces unnecessary waste over time. Increased recycling at the household level reduces these problems of increasing solid waste generation. The most pressing challenge in source separation and recycling practice is public attitudes towards making source separation and recycling separation a habit. Consequently, the sense of collective responsibility and concerns about the implications of not separating waste are also somewhat deficient. Therefore, the results lend insight into four implications for the industry.

This study, through Rasch measurement theory, adds to the literature in the area of SWM with a specific focus on comparing barriers and motivations between the P&R and F&B industries in Malaysia as an emerging economy. There are four specific findings of this study, two relating to the barriers (lack of skills and qualifications and lack of closed-loop control) and the other two pertaining to the motivation factors (cost savings and business model), which perform differently for the two studied industries.

There are two limitations of this study. The first is the sample size. Nineteen companies were studied, 10 from the P&R industry and 9 from the F&B industry. The two industries have important differences in terms of perishability, competition, and lifecycle but have commonalities as the largest contributors to solid waste (Dinie et al. 2013; Pham Phu et al. 2018). The 19 studied companies had good heterogeneity in terms
of ownership (Malaysian and non-Malaysian), company age, and sales turnover. However, future studies can include more organizations from both the P&R and F&B industries for additional insights and perspectives. The second limitation is the geographical context chosen, Malaysia. This study was based on companies operating in both sectors inside Malaysia only. Malaysia has long struggled to reduce solid waste and accordingly has attracted much legislation and policy-making attention (Ncube et al., 2021). However, it is appropriate to expand the countries, regions, and territories to obtain value from a greater diversity of countries. Therefore, more categorization of items within the P&R and F&B industries is needed.

Author contribution Mansoor Ahmed Soomro: conceptualizing, original version, data analysis; Mohd Helmi Ali: conceptualizing, original version and finalizing the final version; Suhaiza Zailani: conceptualizing, data collection, editing final version; Ming-Lang Tseng: conceptualizing, finalizing the final version; Zafr Mohd Makhbul: conceptualizing, editing.

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Declarations

Competing interests The authors declare no competing interests.

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