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OPERATIONALIZATION OF IMPORTANCE-PERFORMANCE ANALYSIS WITH NINE CATEGORIES AND TESTED FOR GREEN PRACTICES AND FINANCIAL EVALUATION

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Abstract. The Importance-Performance Analysis is a widely used diagnostic tool in many fields of economic activity, such as: transport, health, construction, public food industry, finance, banking, sustainable activities, etc. Despite its use for over 40 years in many economic and social fields, this tool has some important drawbacks that affect the accuracy of managerial decisions. Over time, many variants for improving the standard Importance-performance matrix have been proposed. The aim of our research is to propose a method to solve one of the biggest problems of the standard Importance-Performance Analysis, respectively a method of boosting confidence in the positioning of attributes in the matrix. We use a mathematical method, inspired by classification theory tools, to apply the nine categories division of attributes in the importance-performance plane. Moreover, we introduce a level of confidence in a nine categories Importance-performance matrix, which helps the practitioners to prioritize a decision on attributes, according to the resources, managerial plan, competition, etc. We test and discuss the effectiveness of the new method on two studies: on the green practices in educational restaurant operations and on the financial performance evaluation.

Keywords: evaluation, diagnosis tool, confidence, decision making, importance-performance analysis (IPA), prototype, partition, economic activities.

JEL Classification: C61, D81, M31.

Introduction

Today's turbulent business environment is marked by rapid advancements in technology and global events such as the COVID-19 pandemic and, most recently, the conflict in Ukraine has increased the need for efficient decision-making tools which organizations' manage-

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ment can easily use. Moreover, under pressure for a low carbon/sustainable economy (e.g., Ionescu, 2021a), how to compete with appropriate products has become a success key factor. As organizations struggle to compete with high-quality products at lower costs, how a decision-maker can diagnose the performance of different goods or services attributes is becoming a crucial one.

The Importance-Performance Analysis (IPA) proposed by Martilla and James (1977) has been credited as a valuable business tool for identifying significant attributes regarding their urge for managerial action. As a result, many studies have been conducted in various fields of activity, especially in evaluating the satisfaction with the quality of services, as Sever (2015) states. It should be emphasized that the IPA technique is seeking to widen its topics of interest. This research can be seen in different optimizations proposed both to overcome several important drawbacks of the IPA matrix in its standard form (Mount, 2000; Oh, 2001; Bacon, 2003; Ban et al., 2016, 2019) and to assess the impact of new business requests such as digitization or moving towards green products/processes (Patiar et al., 2017; McLeay et al., 2017; Nam & Lee, 2019; Chaisomboon et al., 2020; Esmailpour et al., 2020).

The optimization developments of IPA have been extensively studied, but one critical problem seems to overwhelm most method research studies, i.e., the different divisions of the IPA matrix/grid. For example, Oh (2001) highlighting ten weaknesses of the standard IPA proposed building additional crosshairs into each quadrant of the IPA grid as a measure that can better classify attributes. A broader analysis of the different applications of IPA conducted by Bacon (2003) showed that a diagonal line approach offers a more continuous transitions in the inferred priorities. Moreover, the above-mentioned author assiduously pointed out that there has been a particular focus on the optimal positioning of the thresholds that divide the plot into quadrants as a basis of sound practice, but the mathematical difference between importance and performance merely projects an intuitive rather than a precise meaning.

A considerable and widespread problem with standard IPA is the positioning of attributes close to the axes, which suggests that it could be positioned in more than one quadrant or that there is a hierarchy of attributes within the quadrants, after belonging to the quadrant. A notable attempt to resolve this ambiguity of standard IPA is made by Albrecht and Bradford (1990) who proposed a prioritization of attributes by comparing the importance and associated performance in the form of a nine-quadrant matrix. However, they do not propose any rigorous methodology for constructing dials.

Since then, an essential part of the research was mainly focused on understanding the operational issues related to distinguishing between the attributes that are positioned in the same quadrant (Tarrant & Smith, 2002) and finding the optimal positioning of the thresholds that divide the plot into quadrants (Bacon, 2003). These categories of studies are challenging from the point of view of boosting confidence in the positioning of attributes in the matrix (e.g., Albrecht & Bradford, 1990; Levine et al., 2005; Wu & Shieh, 2009), and few exists (e.g., Dwyer et al., 2016; Ban et al., 2016, 2019; Nazari-Shirkouhi et al., 2020) to help us create an understanding of how a managerial tool/technique for decision making can be improved.

Wu and Shieh (2009) propose a similar but scientifically based method, but without reference to Albrecht and Bradford (1990). Wu and Shieh (2009) integrate confidence intervals in importance-performance analysis to eliminate false decisions. A weak point of the method proposed by them is that the variability in relation to an attribute influences the size of the confidence intervals, ie all the attributes studied. In this way, an item could be positioned at confidence intervals, which means that we cannot make a decision about it, even if its variability is low.

The present paper aims to present a new way of solving the main IPA problem, i.e., the distribution of attributes within the nine quadrants IPA matrix/grid of Albrecht and Bradford (1990) using a confidence value. The method we propose overcomes the problems identified above and brings the benefits of rigor and flexibility of decision-making.

Accordingly, we developed a Nine-Quadrant IPA Method Improved with a Confidence Value (9Qc-IPA) with a twofold undertaking: (1) to form nine-category of attributes by gathering around a prototype the attributes which satisfy a distance criterion in the importance-performance plane (9Q-IPA); (2) to introduce the possibility of influencing the size of quadrants in the 9Q-IPA method through managerial abilities, for a better equilibrium between the ambiguous and unambiguous categories in the distribution of attributes employing a confidence value that can be (9Qc-IPA). Moreover, using two illustrative examples, we showed how our newly developed 9Qc-IPA contributes to refining managerial decisions related to attributes by comparing our results with those obtained with the pre-existent IPA methods.

The paper is organized as follows. We mention the "Theoretical Framework" in Section 1. Section 2 "Proposed Nine-Quadrant IPA Method (9Q-IPA)" is dedicated to our proposal with respect to a nine categories importance-performance analysis. From practical reasons, the method is extended in Section 3 "Nine-Quadrant IPA Method Improved with a Confidence Value (9Qc-IPA)" such that we can dispose from a confidence level. The proposed method becomes more adaptable to various practical contexts. The effectiveness of the method is tested on the green practices in educational restaurant operations and on the evaluation of the financial performance in Section 4.

The next section presents the theoretical background of the research problem, the fields of application of the method.

1. Theoretical framework

The IPA literature to date, to our best knowledge, doesn't offer a newer, more agile, and pragmatic tool for managing day-to-day operational decisions (e.g., the decision to take different types or levels of risk, to optimize resource allocation accordingly a value proposition or to increase rigor or response complexity to assess preparedness for post-pandemic conditions). Three research principles guided our literature review section: (1) it should get to the point without forcing the reader to wade through much text; (2) there should be plenty of graphic representation of our proposed method; and (3) the rationale for each analytical step of method development should be plainly stated. In short, we need to focus on new and potentially helpful knowledge if we are to continue to be relevant as business scholars.

Most of what is submitted to business journals is fine-tuning to what we already know about IPA, even in its standard or improved form. In our opinion, we cannot keep going further with the same old mathematical foundation used in different fields of economic activity. For example, as Sever (2015), the importance-performance analysis is applied in many fields of activity, especially in evaluating satisfaction with the quality of services.

Further, we will mention relatively recent studies where IPA was applied in its standard or improved form. For example, revised forms of IPA are applied in air transport by Lin and Vlachos (2018), Hongli (2018), and Nam and Lee (2019). Standard IPA has been successfully applied to public bus transportation by Chaisomboon et al. (2020) and Esmailpour et al. (2020). In higher education, IPA has been applied in assessing the impact of virtual space on the learning experience (Patiar et al., 2017). McLeay et al. (2017) applied IPA analysis at three levels to assess the gap between the importance and performance associated by students with quality attributes. Also, Wohlfart and Hovemann (2019) used two comparative IPAs to identify the information asymmetries between the labor market and higher education. Padlee et al. (2019) applied IPA to three dimensions of university activity: teaching quality, research quality, and internationalization. In medical services, Izadi et al. (2017) applied standard IPA to measure the quality of services provided to the patients in the surgical and medical departments. Rau et al. (2017) applied IPA to evaluate the functions of a medical data recording platform. Aeyels et al. (2018) applied IPA to ST-elevation myocardial infarction critical interventions. Another application of IPA in medical services aimed to identify the educational needs of nursing simulation instructors (Roh et al., 2019). A combination of the SERVQUAL model and IPA is applied in evaluating long-term geriatric care (Shieh et al., 2019).

The issue of sustainability was addressed in the IPA analysis in construction and tourism and restaurants, among others. In the field of construction, Chang et al. (2017) proposed transition pathways toward sustainability for construction enterprises by operating an IPA, and Wang et al. (2019) and Xie et al. (2020) used IPA in the evaluation of critical sustainability aspects associated with prefabricated buildings. Zhang et al. (2021) proposed an analysis of the implementation of corporate social responsibility for construction firms via IPA. In the tourism and hospitality industry, IPA has been applied in several areas for sustainable tourism (Boley et al., 2017), destinations (Deng & Pierskalla, 2018; Rašovská et al., 2021), parks, hotels, restaurants, tour guides, sports centers, spa centers, conferences.

Let us look at IPA research, which should be, at its core, applied to business. We find a lot of the research is not helping practitioners with their problems, especially in uncertain environments like the COVID-19 crisis. This error can result in misguided priority setting because especially the non-proportional consumer' satisfiers led to developing an importance/performance map where current performance is plotters against optimal performance. In conclusion, we proposed a mathematical optimization of the IPA technique that can be expanded to address new and challenging issues of post-covid economic recovery.

The IPA proposed by Martilla and James (1977), referred in this paper as *classical IPA* or *standard IPA*, assumes the distribution of a given set of attributes into four categories, according with the description in Figure 1.

The selection of the optimal positioning of the thresholds – a vertical axis corresponding to performance and a horizontal axis corresponding to importance – in standard IPA is a subject of a continuous debate. The grand means of the data or the mid-points of the scales are the usual choices.

A sensitive aspect of the standard IPA, related to the above remark, is the positioning of attributes close to axes, which suggests that different strategies could be applied to an attribute, that is there exists a hierarchy of attributes within the quadrants (Dwyer et al., 2016;

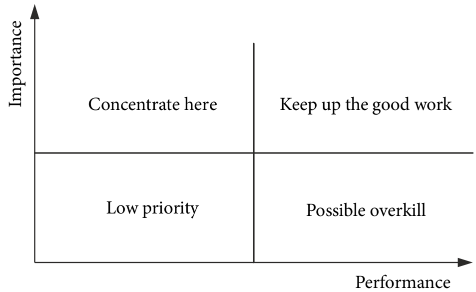

Figure 1. Four categories in standard IPA

Ban et al., 2016). As mentioned by Levine et al. (2005) and Wu and Shieh (2009) a sampling error can place an attribute in one quadrant when in fact it would be in another quadrant, which implies a completely wrong strategy. Moreover, the attributes have different positions in a quadrant, which rank their candidacy in the application of the strategy related to the quadrant. This is a common situation when the standard IPA is applied and it can lead to subjective interpretations. Just as an example, Nazari-Shirkouhi et al. (2020) recently proposed a very rigorous approach to establish the importance and performance of indicators for evaluating higher education institutions. The strategic decisions on indicators are taken by applying standard Importance-Performance Analysis. Unfortunately, more indicators are positioned close to the axes, which leads to sensitive managerial decisions.

A notable attempt to resolve this ambiguity in standard IPA is made by Albrecht and Bradford (1990) who proposed a prioritization of attributes by comparing the importance and associated performance of consumers. Almanza et al. (1994), Joppe et al. (2001) and Dwyer et al. (2016) apply the matrix proposed by Albrecht and Bradford (1990) called *service attribute matrix*.

Wu and Shieh (2009) integrate confidence intervals into importance-performance analysis to eliminate false decisions. Separately, for equal population variances assumption and for unequal population variances assumption, confidence intervals of performance and importance are constructed based on the standard deviation of primary data, therefore the variability of answers in a survey is taken into consideration. These intervals are removed from the importance-performance plane such that only on the remaining attributes a decision is qualified to be made (see Figure 2).

The idea is applied to services of dormitory located in Asia University (Wu & Shieh, 2009), to comparison of Serbia and Slovenia with respect to evaluating tourism businesses strategies (Dwyer et al., 2016) and to the analysis of senior tourists' perceptions of senior friendly destination attributes (Liew et al., 2021, p. 4). A weakness of the method is that the variability with respect to an attribute influences the size of the confidence intervals, that is all the attributes under study. In this way, an item could be positioned into confidence intervals, which means that we cannot take a decision on it, even if its variability is low.

The Fuzzy C-Means algorithm is applied (Ban et al., 2016) to obtain a fuzzy partition of the set of attributes in the importance-performance plane starting from the standard perspective. A membership degree of every attribute to the sets *Keep up the good work*, *Concentrate* *here*, *Low priority* and *Possible overkill* is obtained, against to the forcing categorization in the standard approach.

To overcome the ambiguities in the standard IPA, Albrecht and Bradford (1990) assigned a ranking to the importance scores and performance scores. They assigned *high*, *medium* or *low* to the importance scores and *A*, *B* or *C* to the performance scores. This created nine possible categories of attributes, $A_i, i \in \{1,\ldots,9\}$ as in Figure 3.

By comparing Figures 1 and 3, we could say that *Competitive strength*, *Competitive vulnerability*, *Relative indifference* and *Irrelevant superiority* in the nine categories approach correspond to the interpretations in the standard IPA, namely *Keep up the good work*, *Concentrate here*, *Low priority* and *Possible overkill*, respectively. The main advantage of the method is that, by using more categories, the attributes which are near of axes in the standard approach, now they are assigned to the *Grey zone* or a newly created cell: *High B*, *Medium C*, *Low B* or *Medium A*, suggestively called for their ambiguity. In this way, the strategic managerial decisions on attributes in *Competitive strength* (*Keep up the good work*), *Competitive vulnerability* (*Concentrate here*), *Relative indifference* (*Low priority*), *Irrelevant superiority* (*Possible overkill*) become more effective and the ambiguities are eliminated because we obtain a distribution into four categories of attributes with a greater degree of confidence in the outputs.

An important weakness of the nine categories importance-performance analysis is that the authors do not explain how the thresholding axes – two vertical axes corresponding

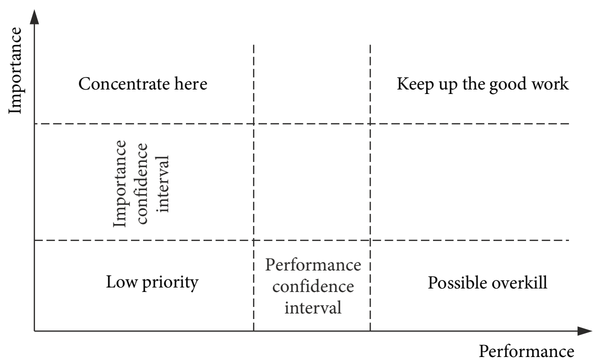

Figure 2. Confidence intervals in standard IPA

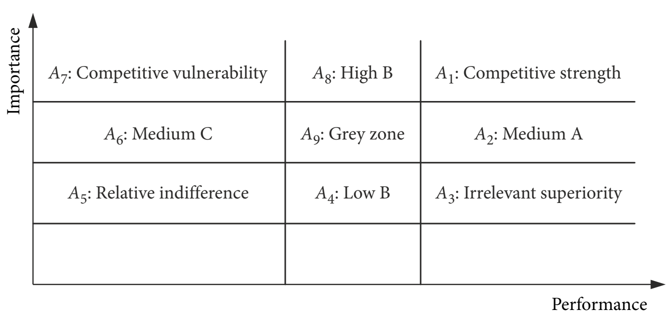

Figure 3. Nine categories approach in IPA

to performance and two horizontal axes corresponding to importance – are placed in the performance-importance plane. The nine categories approach is applicable to studies with a large number of attributes or if we want to avoid the vagueness due to sampling errors or subjective interpretation of answers. As examples, Hudson and Shephard (1998) applied a detailed questionnaire on 97 attributes with respect to importance and performance of services of a ski resort. The aim of the study of Choi and Boger Jr. (2000) was to evaluate state association meeting planners' satisfaction by considering the performance and importance of 45 attributes. An importance-performance analysis on 48 strategic activities dedicated to promote business and destination competitiveness was elaborated by Dwyer et al. (2016).

In the next section we present the method proposed by us, starting from his idea Albrecht and Bradford (1990).

2. Proposed nine-quadrant IPA method (9Q-IPA)

In this section we complete the idea from Albrecht and Bradford (1990) by proposing a nine-quadrant IPA (9Q-IPA) method, in fact a rigorous procedure to determine the thresholding axes into importance-performance plane.

Let $\left\{a^1,\ldots,a^n\right\}$ be a set of attributes (they can be also indicators or strategic activities, according with the problem under study) and we denote by x^j, the pair (*performance*, *importance*) corresponding to the attribute a^j, that is $x^j=\left(p^j,w^j\right), j\in\left\{1,\ldots,n\right\}$.

We develop our method by keeping the standard categories of attributes in the nine categories importance-performance analysis (Albrecht & Bradford, 1990), that is A_1: *Competitive strength*, A_2: *Medium A*, A_3: *Irrelevant superiority*, A_4: *Low B*, A_5: *Relative indifference*, A_6: *Medium C*, A_7: *Competitive vulnerability*, A_8: *High B* and A_9: *Grey zone* (see Figure 3). We choose

$$L_1=\left(M_p,M_w\right)=\left(\max_{1\le j\le n} p^j,\max_{1\le j\le n} w^j\right); \tag{1}$$

$$L_2=\left(M_p,\mu_w\right)=\left(\max_{1\le j\le n} p^j,\sum_{1\le j\le n} w^j/n\right); \tag{2}$$

$$L_3=\left(M_p,m_w\right)=\left(\max_{1\le j\le n} p^j,\min_{1\le j\le n} w^j\right); \tag{3}$$

$$L_4=\left(\mu_p,m_w\right)=\left(\sum_{1\le j\le n} p^j/n,\min_{1\le j\le n} w^j\right); \tag{4}$$

$$L_5=\left(m_p,m_w\right)=\left(\min_{1\le j\le n} p^j,\min_{1\le j\le n} w^j\right); \tag{5}$$

$$L_6=\left(m_p,\mu_w\right)=\left(\min_{1\le j\le n} p^j,\sum_{1\le j\le n} w^j/n\right); \tag{6}$$

$$L_7=\left(m_p,M_w\right)=\left(\min_{1\le j\le n} p^j,\max_{1\le j\le n} w^j\right); \tag{7}$$

$$L_8 = \left(\mu_p, M_w\right) = \left(\sum_{1 \le j \le n} p^j / n, \max_{1 \le j \le n} w^j\right) \tag{8}$$

and

$$L_9 = \left(\mu_p, \mu_w\right) = \left(\sum_{1 \le j \le n} p^j / \mathrm{n}, \sum_{1 \le j \le n} w^j / n\right) \tag{9}$$

as the corresponding prototypes, represented in Figure 4. The prototypes are chosen as the most representative (regarded as the ideal) elements of each category. Of course, most often the prototypes do not correspond to the existing attributes, they are hypothetical. Just as an example, $L_1 = \left(\max_{1 \le j \le n} p^j, \max_{1 \le j \le n} w^j\right)$ is the prototype of the category *Competitive strength* because attributes with a high performance and a high importance must be included here.

Our idea is to form a category of attributes by gathering around a prototype the attributes which satisfy a distance criteria in the importance-performance plane. Formally, for a fixed attribute $a^j, j \in \{1, \ldots, n\}$, that is a point $x^j = \left(p^j, w^j\right)$, $j \in \{1, \ldots, n\}$, in the performance-importance plane, we calculate the distances $d\left(x^j, L_i\right), i \in \{1, \ldots, 9\}$, where d denotes any distance on $\mathbb{R}^2$. Finally, the attribute a^j is included in the category $A_k, k \in \{1, \ldots, 9\}$ if and only if $d\left(x^j, L_k\right) \le d\left(x^j, L_i\right)$ for every $i \in \{1, \ldots, 9\}, k \ne i$, that is the closest prototype from a^j is L_k. Of course, the first choice is the Euclidean distance on $\mathbb{R}^2$, that is $d = d_E$, where

$$d_E^2\left(\left(x_1, x_2\right), \left(y_1, y_2\right)\right) = \left(x_1 - y_1\right)^2 + \left(x_2 - y_2\right)^2,$$

but another distance can be considered too. The categories of attributes with respect to d_E are determined as follows:

$$A_1 = \left\{a^j : p^j > \frac{1}{2}M_p + \frac{1}{2}\mu_p, w^j > \frac{1}{2}M_w + \frac{1}{2}\mu_w\right\}; \tag{10}$$

$$A_2 = \left\{a^j : p^j > \frac{1}{2}M_p + \frac{1}{2}\mu_p, \frac{1}{2}m_w + \frac{1}{2}\mu_w < w^j \le \frac{1}{2}M_w + \frac{1}{2}\mu_w\right\}; \tag{11}$$

$$A_3 = \left\{a^j : p^j > \frac{1}{2}M_p + \frac{1}{2}\mu_p, w^j \le \frac{1}{2}m_w + \frac{1}{2}\mu_w\right\}; \tag{12}$$

$$A_4 = \left\{a^j : \frac{1}{2}m_p + \frac{1}{2}\mu_p < p^j \le \frac{1}{2}M_p + \frac{1}{2}\mu_p, w^j \le \frac{1}{2}m_w + \frac{1}{2}\mu_w\right\}; \tag{13}$$

$$A_5 = \left\{a^j : p^j \le \frac{1}{2}m_p + \frac{1}{2}\mu_p, w^j \le \frac{1}{2}m_w + \frac{1}{2}\mu_w\right\}; \tag{14}$$

$$A_6 = \left\{a^j : p^j \le \frac{1}{2}m_p + \frac{1}{2}\mu_p, \frac{1}{2}m_w + \frac{1}{2}\mu_w < w^j \le \frac{1}{2}M_w + \frac{1}{2}\mu_w\right\}; \tag{15}$$

$$A_7 = \left\{a^j : p^j \le \frac{1}{2}m_p + \frac{1}{2}\mu_p, w^j > \frac{1}{2}M_w + \frac{1}{2}\mu_w\right\}; \tag{16}$$

$$A_8 = \left\{a^j : \frac{1}{2}m_p + \frac{1}{2}\mu_p \left\langle p^j \le \frac{1}{2}M_p + \frac{1}{2}\mu_p, w^j \right\rangle \frac{1}{2}M_w + \frac{1}{2}\mu_w\right\} \tag{17}$$

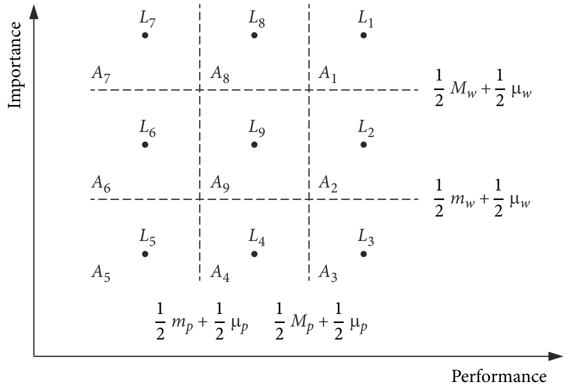

Figure 4. Nine categories approach, the associated prototypes and thresholding axes

and

$$A_9 = \left\{a^j : \frac{1}{2}m_p + \frac{1}{2}\mu_p < p^j \le \frac{1}{2}M_p + \frac{1}{2}\mu_p, \frac{1}{2}m_w + \frac{1}{2}\mu_w < w^j \le \frac{1}{2}M_w + \frac{1}{2}\mu_w\right\}, \quad (18)$$

where

$$m_p = \min_{1\le j\le n} p^j, M_p = \max_{1\le j\le n} p^j, \mu_p = \sum_{1\le j\le n} p^j / n,$$
$$m_w = \min_{1\le j\le n} w^j, M_w = \max_{1\le j\le n} w^j, \mu_w = \sum_{1\le j\le n} w^j / n.$$

We point out that the strict inequalities in Eqs (10)–(18) are arbitrarily chosen, such that $\left\{A_i, i \in \{1,\ldots,9\}\right\}$ form a partition in the importance performance plane, but without any other rule. Anyway, in practical applications the possibility of equalities in Eqs (10)–(18) is extremely low. We can obtain the above sets $A_i, i \in \{1,\ldots,9\}$ by a geometric reasoning, based on Figure 4, but we prefer a direct proof. Indeed, with the above notations, we get

$$d_E\left(x^j, L_1\right) < d_E\left(x^j, L_2\right)$$

if and only if

$$w^j > \frac{1}{2}M_w + \frac{1}{2}\mu_w, \quad (19)$$

$$d_E\left(x^j, L_1\right) < d_E\left(x^j, L_3\right)$$

if and only if

$$w^j > \frac{1}{2}M_w + \frac{1}{2}m_w, \quad (20)$$

$$d_E\left(x^j, L_1\right) < d_E\left(x^j, L_4\right)$$

if and only if

$$p^j\left(M_p - \mu_p\right) + w^j\left(M_w - m_w\right) > \frac{1}{2}M_p^2 - \frac{1}{2}\mu_p^2 + \frac{1}{2}M_w^2 - \frac{1}{2}m_w^2, \quad (21)$$

$$d_E\left(x^j, L_1\right) < d_E\left(x^j, L_5\right)$$

if and only if

$$p^j\left(M_p - m_p\right) + w^j\left(M_w - m_w\right) > \frac{1}{2}M_p^2 - \frac{1}{2}m_p^2 + \frac{1}{2}M_w^2 - \frac{1}{2}m_w^2, \quad (22)$$

$$d_E\left(x^j, L_1\right) < d_E\left(x^j, L_6\right)$$

if and only if

$$p^j\left(M_p - m_p\right) + w^j\left(M_w - \mu_w\right) > \frac{1}{2}M_p^2 - \frac{1}{2}m_p^2 + \frac{1}{2}M_w^2 - \frac{1}{2}\mu_w^2, \tag{23}$$

$$d_E\left(x^j, L_1\right) < d_E\left(x^j, L_7\right)$$

if and only if

$$p^j > \frac{1}{2}M_p + \frac{1}{2}m_p, \tag{24}$$

$$d_E\left(x^j, L_1\right) < d_E\left(x^j, L_8\right)$$

if and only if

$$p^j > \frac{1}{2}M_p + \frac{1}{2}\mu_p \tag{25}$$

and

$$d_E\left(x^j, L_1\right) < d_E\left(x^j, L_9\right)$$

if and only if

$$p^j\left(M_p - \mu_p\right) + w^j\left(M_w - \mu_w\right) > \frac{1}{2}M_p^2 - \frac{1}{2}\mu_p^2 + \frac{1}{2}M_w^2 - \frac{1}{2}\mu_w^2. \tag{26}$$

If $a^j \in A_1$ then we easily prove that Eqs $(19)-(26)$ are satisfied. Reciprocally, if Eqs $(19)-(26)$ are verified then Eqs (19) and (25) are true, that is $a^j \in A_1$. The above proof is similar for each set$A_i, i \in \{1,\ldots,9\}$.

From Eqs (10)–(18) we can conclude that 9Q-IPA is obtained by considering

$$p_m = \frac{1}{2}\min_{1\le j\le n} p^j + \frac{1}{2}\sum_{1\le j\le n} p^j / n = \frac{1}{2}m_p + \frac{1}{2}\mu_p \tag{27}$$

and

$$p_M = \frac{1}{2}\max_{1\le j\le n} p^j + \frac{1}{2}\sum_{1\le j\le n} p^j / n = \frac{1}{2}M_p + \frac{1}{2}\mu_p \tag{28}$$

as the thresholding axes for performance and

$$w_m = \frac{1}{2}\min_{1\le j\le n} w^j + \frac{1}{2}\sum_{1\le j\le n} w^j / n = \frac{1}{2}m_w + \frac{1}{2}\mu_w \tag{29}$$

and

$$w_M = \frac{1}{2}\max_{1\le j\le n} w^j + \frac{1}{2}\sum_{1\le j\le n} w^j / n = \frac{1}{2}M_w + \frac{1}{2}\mu_w \tag{30}$$

as the thresholding axes for importance, in the performance-importance plane (see Figure 4).

We exemplify by applying our proposed method for the data in Table 1 (Wilkins, 2010).

Table 1. Performance and importance of attributes (source: Wilkins, 2010)

	p^j	w^j		p^j	w^j		p^j	w^j
a^1	6.6589	6.1640	a^{11}	7.5626	8.0315	a^{21}	8.7574	9.1915
a^2	7.7316	8.3809	a^{12}	7.6538	7.5006	a^{22}	8.2126	8.2248
a^3	7.3670	7.4968	a^{13}	6.3616	6.1611	a^{23}	5.9001	6.5939
a^4	7.1884	7.1493	a^{14}	7.8731	7.5392	a^{24}	6.0747	5.9920
a^5	6.5738	6.3472	a^{15}	7.3312	6.4275	a^{25}	6.7570	7.3702
a^6	6.7906	6.1654	a^{16}	7.5083	7.1589	a^{26}	5.6130	5.4855
a^7	7.3770	6.8525	a^{17}	7.9000	6.8179	a^{27}	7.4445	7.1225
a^8	6.6815	5.5377	a^{18}	8.8642	9.1911	a^{28}	6.6628	6.2418
a^9	7.6865	6.9066	a^{19}	8.3237	8.9142	a^{29}	7.5356	7.3916
a^{10}	7.0893	6.6169	a^{20}	8.2945	8.8664	a^{30}	7.4284	7.2362

Because $\sum_{1\le j\le n} p^j / n = 7.307$, $\sum_{1\le j\le n} w^j / n = 7.170$, $\max_{1\le j\le n} p^j = 8.8642$, $\min_{1\le j\le n} p^j = 5.6130$, $\max_{1\le j\le n} w^j = 9.1915$, $\min_{1\le j\le n} w^j = 5.4855$, by (27)–(30) we obtain the values of the thresholds and implicitly the thresholding axes as $p_M = 8.0856, p_m = 6.460, w_m = 6.3277$ and $w_M = 8.1808$, therefore the following partition of the set of attributes:

$$
\begin{aligned}
&A_1 = \left\{a^{18}, a^{19}, a^{20}, a^{21}, a^{22}\right\},\\
&A_2 = \varnothing,\\
&A_3 = \varnothing,\\
&A_4 = \left\{a^{1}, a^{6}, a^{8}, a^{28}, a^{30}\right\},\\
&A_5 = \left\{a^{13}, a^{24}, a^{26}\right\},\\
&A_6 = \left\{a^{23}\right\},\\
&A_7 = \varnothing,\\
&A_8 = \left\{a^{2}\right\},\\
&A_9 = \left\{a^{3}, a^{4}, a^{5}, a^{7}, a^{9}, a^{10}, a^{11}, a^{12}, a^{14}, a^{15}, a^{16}, a^{17}, a^{25}, a^{27}, a^{29}\right\}.
\end{aligned}
$$

In the next section we complete the method proposed by us with a parameter that allows different approaches. We present this method in two steps to highlight our contributions.

3. Nine-quadrant IPA method improved with a confidence value (9Qc-IPA)

We improve the 9Q-IPA method described in the previous section by introducing a parameter that gives a certain elasticity to our approach.

As we can see, by applying Eqs (10)–(18), only on few attributes we can establish a clear decision corresponding to the unambiguous categories A_1, A_3, A_5 and A_7 (8 from 30 attributes in the case of Wilkins (2010) data – see the previous section, 5 from 48 attributes in the case of Dwyer et al. (2016) data – see the next section and 3 from 45 attributes in the case of Yang et al. (2018) data – see the next section too), many attributes/indicators/strategic activities being included in the ambiguous categories A_2, A_4, A_6, A_8 and A_9. We could consider that it is an advantage of the method proposed in Section 2 because a set of secure attributes – from the point of view of the managerial decision – is determined. On the other hand, the set of attributes in the ambiguous categories could be considered too large. From a geometrical point of view the reason of this situation is simple: denoting by S_i the area corresponding to $A_i, i \in \{1,\ldots,9\}$ (Figure 5) we immediately have $S_2 + S_4 + S_6 + S_8 + S_9 = 3\left(S_1 + S_3 + S_5 + S_7\right)$ and $S_9 = S_1 + S_3 + S_5 + S_7$, that is the sum of grey areas is three times higher than the sum of clear areas and the sum of all clear areas is equal with the area corresponding to the category A_9.

We overcome the above problem by introducing a confidence value $\alpha \in [0,1)$ in Eqs (10)–(18), the result being 9Qc-IPA method, a generalization of 9Q-IPA method. We open the possibility of influencing the size of quadrants in the 9Q-IPA method described in the previous section, for a better equilibrium between the ambiguous and clear categories in the distribution of attributes. An optimum of the confidence value is proposed at the end of this section, but its choice essentially depends from the managerial strategy.

By keeping the idea in 9Q-IPA method and the notations in the previous section, we introduce the following partition of the set of attributes, which depends from a confidence value $\alpha \in [0,1)$:

$$A_1^\alpha = \left\{a^j : p^j > \alpha M_p + (1-\alpha)\mu_p, w^j > \alpha M_w + (1-\alpha)\mu_w\right\}; \tag{31}$$

$$A_2^\alpha = \left\{a^j : p^j > \alpha M_p + (1-\alpha)\mu_p, \alpha m_w + (1-\alpha)\mu_w < w^j \le \alpha M_w + (1-\alpha)\mu_w\right\}; \tag{32}$$

$$A_3^\alpha = \left\{a^j : p^j > \alpha M_p + (1-\alpha)\mu_p, w^j \le \alpha m_w + (1-\alpha)\mu_w\right\}; \tag{33}$$

$$A_4^\alpha = \left\{a^j : \alpha m_p + (1-\alpha)\mu_p < p^j \le \alpha M_p + (1-\alpha)\mu_p, w^j \le \alpha m_w + (1-\alpha)\mu_w\right\}; \tag{34}$$

$$A_5^\alpha = \left\{a^j : p^j \le \alpha m_p + (1-\alpha)\mu_p, w^j \le \alpha m_w + (1-\alpha)\mu_w\right\}; \tag{35}$$

$$A_6^\alpha = \left\{a^j : p^j \le \alpha m_p + (1-\alpha)\mu_p, \alpha m_w + (1-\alpha)\mu_w < w^j \le \alpha M_w + (1-\alpha)\mu_w\right\}; \tag{36}$$

$$A_7^\alpha = \left\{a^j : p^j \le \alpha m_p + (1-\alpha)\mu_p, w^j > \alpha M_w + (1-\alpha)\mu_w\right\}; \tag{37}$$

$$A_8^\alpha = \left\{a^j : \alpha m_p + (1-\alpha)\mu_p \left\langle p^j \le \alpha M_p + (1-\alpha)\mu_p, w^j \right\rangle \alpha M_w + (1-\alpha)\mu_w\right\} \tag{38}$$

and

$$A_9^\alpha = \left\{a^j : \alpha m_p + (1-\alpha)\mu_p < p^j \le \alpha M_p + (1-\alpha)\mu_p, \right. \tag{39}$$

$$\left. \alpha m_w + (1-\alpha)\mu_w < w^j \le \alpha M_w + (1-\alpha)\mu_w\right\},$$

that is

$$p_{m,\alpha} = \alpha m_p + (1-\alpha)\mu_p; \tag{40}$$

$$p_{M\,\alpha} = \alpha M_p + (1-\alpha)\mu_p; \tag{41}$$

$$w_{m,\alpha} = \alpha m_w + (1-\alpha)\mu_w \tag{42}$$

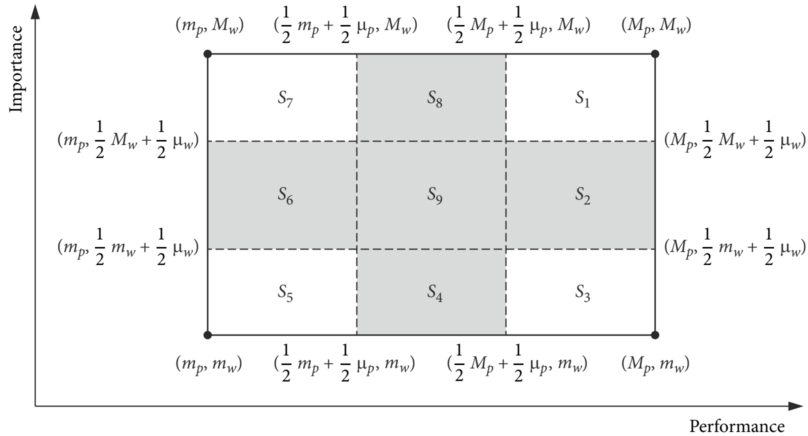

Figure 5. Geometrical interpretation of 9Q-IPA method

and

$$w_{M,\alpha} = \alpha M_w + (1-\alpha)\mu_w \tag{43}$$

are the thresholding axes in the importance-performance plane, corresponding to 9Qc-IPA method.

For $\alpha = \frac{1}{2}$ we obtain $A_i^{\frac{1}{2}} = A_i$, for every $i \in \{1,\ldots,9\}$, that is the partition of attributes/indicators given by 9Q-IPA method (see Eqs (10)–(18)). Because $A_2^0 = A_4^0 = A_6^0 = A_8^0 = A_9^0 = \varnothing$, for $\alpha = 0$ the nine categories approach degenerates into standard four categories, that is importance-performance analysis having as thresholding axes the grand means $\mu_p = \sum_{1\le j\le n} p^j / n$ and $\mu_w = \sum_{1\le j\le n} w^j / n$.

For a fixed $\alpha \in [0,1)$, we denote by $S_i^\alpha, i \in \{1,\ldots 9\}$ (see Figure 6) the area corresponding to the set $A_i^\alpha, i \in \{1,\ldots,9\}$ given by Eqs (31)–(39). We get

$$S_1^\alpha + S_3^\alpha + S_5^\alpha + S_7^\alpha = (1-\alpha)\ \left(M_p - m_p\right)\left(M_w - m_w\right) \tag{44}$$

and

$$S_2^\alpha + S_4^\alpha + S_6^\alpha + S_8^\alpha + S_9^\alpha = \alpha\left(2-\alpha\right)\left(M_p - m_p\right)\left(M_w - m_w\right). \tag{45}$$

Therefore, if the value of α decreases, then the number of attributes situated into a clear category ($A_1^\alpha, A_3^\alpha, A_5^\alpha$ or A_7^α) increases. Contrariwise, as the value of α increases, the area $S_1^\alpha + S_3^\alpha + S_5^\alpha + S_7^\alpha$ decreases, that is the number of attributes/indicators into an unambiguous category decreases too. The behaviour of the 9Qc-IPA method with respect to different levels of the confidence value is illustrated in Figure 7 (from a to d).

The confidence value α is a free parameter in 9Qc-IPA method, which can be determined based on the experience of the decider, by taking into account the information about the competitors or through other methodologies. It is very interesting that by imposing a rather natural condition as the sum of areas corresponding to the ambiguous categories, that is $S_2^\alpha + S_4^\alpha + S_6^\alpha + S_8^\alpha + S_9^\alpha$, to be equal with the sum of the areas corresponding to clear categories, that is $S_1^\alpha + S_3^\alpha + S_5^\alpha + S_7^\alpha$, we obtain a confidence value independent from the input data.

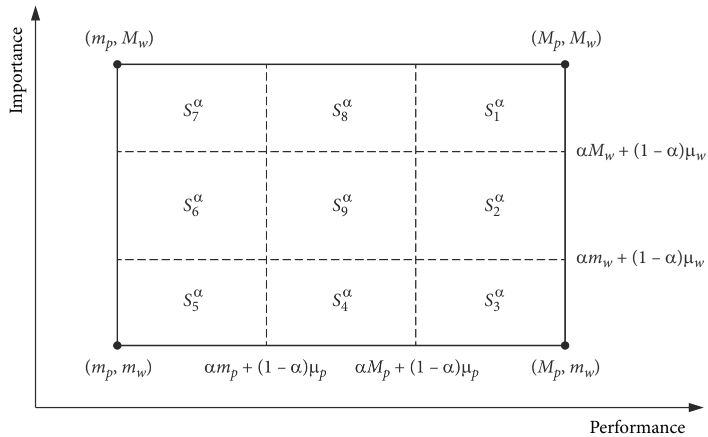

Figure 6. Corresponding areas to the categories of attributes in 9Qc-IPA method

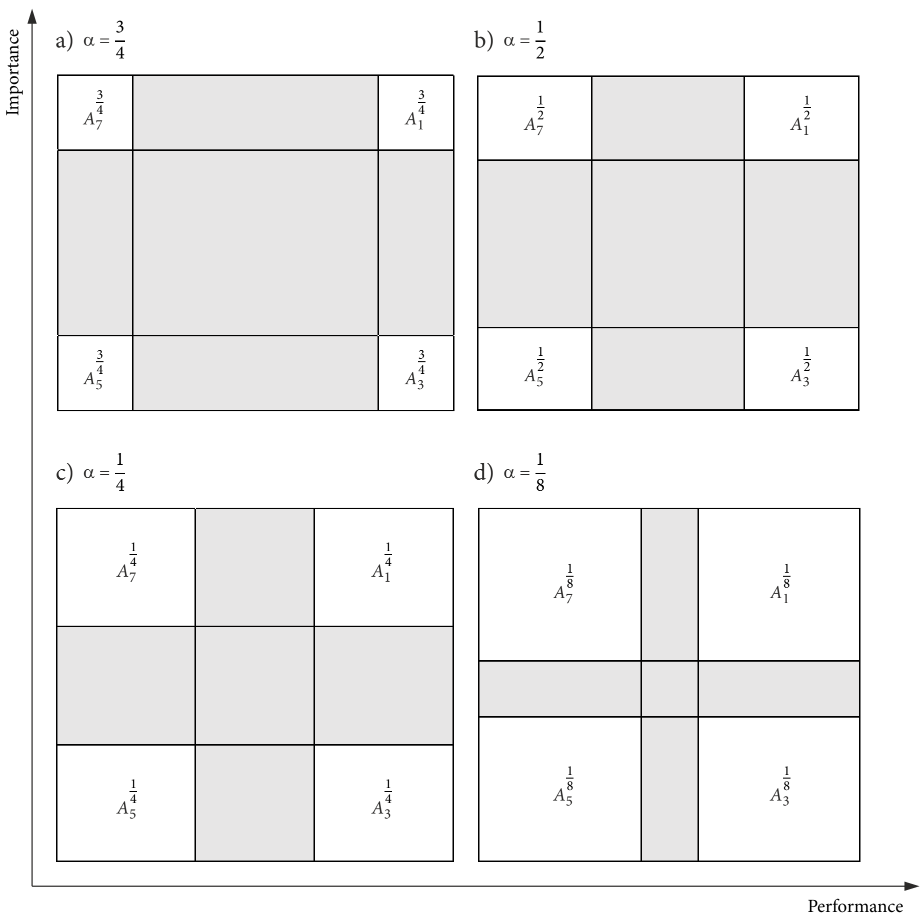

Figure 7. Unambiguous sets of attributes for different confidence values (from a to d)

Indeed, $S_1^\alpha + S_3^\alpha + S_5^\alpha + S_7^\alpha = S_2^\alpha + S_4^\alpha + S_6^\alpha + S_8^\alpha + S_9^\alpha$ if and only if $\alpha = \frac{2-\sqrt{2}}{2}\left(\approx 0.293\right)$. Because this value gives the same chance of an attribute to belong to a clear category or an ambiguous category, we can consider it as an optimum of the confidence value.

In the next chapter we present two examples in which we compare for the same data, "standard" IPA with 9Qc-IPA proposed by us. As we showed in the introduction, IPA is applied in many areas of activity. I chose two different ones: the green practices and the financial one. The purpose was to show how to apply and compare IPA for our method with standard IPA. We did not discuss the list of related variables / indicators because this was not the purpose of our research but the analysis of the method.

4. Illustrative examples for 9Qc-IPA method

4.1. Example for green practices

We consider the data set from Lee et al. (2020) to exemplify and test the above proposed 9Qc-IPA method. The authors looked at 32 green practices – included in Table 2 – from the educational restaurants. According to their belief, "sustainability study at educational restaurants can help various stakeholders in higher education understand its impact on the environment and thus establish new ways to be more responsible for the social and natural environment" (Lee et al., 2020, p. 152).

Table 2. Importance and performance of green practices (source: Lee et al., 2020)

List of green practices	w^j	p^j
A. Monitor billing for indications of possible problems.	3.65	3.02
B. Timely repair of leaks in kitchen equipment and plumbing.	4.31	3.36
C. Low flow/manually triggered rinse nozzles in the dish station.	3.52	3.29
D. Pressure regulated/properly calibrated low flow dish machines and steamer units.	3.59	3.52
E. Thaw procedures that do not depend on running water.	3.85	3.18
F. Manual dish washing procedures that limit free running rinse water.	3.74	3.68
G. Low flow/high efficiency toilets and faucets.	3.88	2.98
H. Service of drinking water to quests only upon request.	3.16	3.76
I. Posted signage in common areas encouraging water conservation.	3.52	2.90
J. Low flow/metered watering systems for interior and exterior landscaping.	3.99	3.48
K. Energy efficient lighting in preparation areas, hoods, refrigerators.	4.25	3.55
L. Energy efficient kitchen equipment such as ovens, holding boxes, steam tables, walk-in and reach-in refrigeration units, ice machine.	4.29	3.23
M. On-going maintenance and timely repair of refrigeration unit seals, gaskets, coils.	4.65	3.41
N. Automatic thermostats programmed for optimal temperature at different times of day or day of week.	4.39	3.57
O. Energy efficient lighting in dining room, bar, restroom, lobby and outside areas.	4.35	3.24
P. Motion sensors to regulate lighting.	4.09	3.33

End of Table 2

List of green practices	w^j	p^j
Q. Energy efficient gas-powered equipment such as range tops, stoves, kettles, water heaters.	4.13	3.24
R. Established solar powered equipment such as water heaters.	3.61	2.67
S. Experimental solar/wind (other) power as a replacement for standard energy sources.	3.57	2.70
T. Purchasing products packaged in recyclable, returnable, reusable containers.	4.26	3.91
U. Purchasing from reputable vendors with recycling protocols practiced at the source.	4.04	3.95
V. In-house recycling protocols for food waste (composting), glass, metal, plastic, paper, cardboard.	4.61	3.82
W. Take out packaging products that are compostable, Biodegradable.	4.34	3.77
X. Established relationships with third party charity feeders for utilization of unused or overproduced food items.	4.01	3.33
Y. Restaurant furnishings made of recycled materials.	3.35	3.16
Z. Environment friendly kitchen cleaning products for dishes, counter tops, floors.	4.09	3.67
Za. Environment friendly dining room and common area cleaning products for linens, tables, bar tops.	4.13	3.71
Zb. Dedicated waste water disposal to keep pollutants from entering storm drains.	4.13	3.48
Zc. Properly maintained grease traps.	4.70	3.86
Zd. Properly maintained kitchen hood ventilation system.	4.68	3.91
Ze. Properly cleaned and maintain dock areas.	4.55	3.95
Zf. Environment friendly fertilizers used in interior and exterior landscaping.	4.26	3.29

By applying the standard importance-performance analysis (described in Section 1) the authors obtained the distribution of attributes in Figure 8, that is the following categories:

Keep up the good work $=\{K,N,T,V,W,Z,Za,Zb,Zc,Zd,Ze\}$,

Concentrate here $=\{B,L,M,O,P,Q,Zf\}$,

Low priority $=\{A,C,E,G,I,R,S,X,Y\}$,

Possible overkill $=\{D,F,H,J,U\}$.

Our intention is to study how 9Qc-IPA refines the standard importance-performance analysis, that is the managerial decisions related to the green practices in educational restaurant operations, by keeping the results of the questionnaires on performance and importance synthesized in Table 2.

We obtain

$$\mu_p=\sum\nolimits_{1\le j\le n} p^j/n=3.435,\mu_w=\sum\nolimits_{1\le j\le n} w^j/n=4.053,\ M_p=\max_{1\le j\le n} p^j=3.95,$$
$$m_p=\min_{1\le j\le n} p^j=2.67,\ M_w=\max_{1\le j\le n} w^j=4.70,\ m_w=\min_{1\le j\le n} w^j=3.16.$$

The partition of the set of green practices is given by (10)–(18) and it corresponds to the thresholding axes $p_m=3.053, p_M=3.693, w_m=3.607$ and $w_M=4.377\left(\text{see}(27)-(30)\right.$ or $\left.(40)-(43)\text{ with }\alpha=\frac{1}{2}\right)$. We get

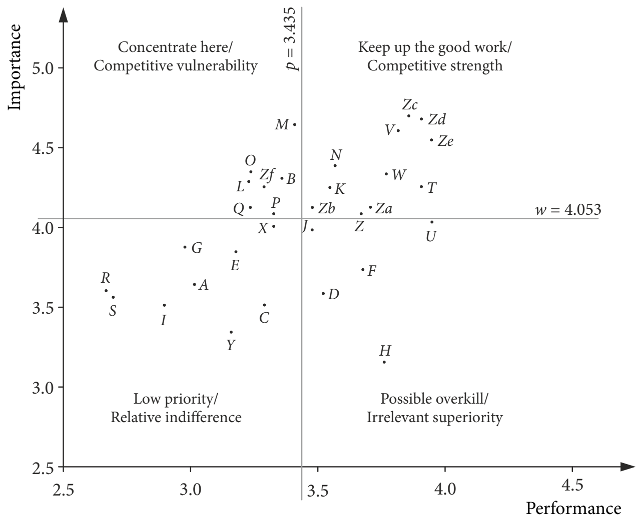

Figure 8. Standard IPA (source: adapted from Lee et al., 2020, p. 149)

$$
\begin{aligned}
&A_1 = A_1^{1/2} = \{V, Zc, Zd, Ze\},\\
&A_2 = A_2^{1/2} = \{T, U, W, Za\},\\
&A_3 = A_3^{1/2} = \{H\},\\
&A_4 = A_4^{1/2} = \{C, D, Y\},\\
&A_5 = A_5^{1/2} = \{I, S\},\\
&A_6 = A_6^{1/2} = \{A, G, R\},\\
&A_7 = A_7^{1/2} = \varnothing,\\
&A_8 = A_8^{1/2} = \{M, N\},\\
&A_9 = A_9^{1/2} = \{B, E, F, J, K, O, P, Q, X, Z, Zb, Zf\}
\end{aligned}
$$

that is a clear decision based on 9Q-IPA method (which corresponds to the confidence value $\alpha = \frac{1}{2}$ in 9Qc-IPA method) can be given on seven green practices: *H*, *I*, *S*, *V*, *Zc*, *Zd*, *Ze* (Figure 9c). The number of items placed in ambiguous categories increases for bigger values of the confidence level. Indeed, if we increase the confidence value from $\alpha = \frac{1}{2}$ to $\alpha = \frac{3}{4}$ then we obtain the thresholding axes (see Eqs (40)–(43)) $p_{m,\frac{3}{4}} = 2.861, p_{M,\frac{3}{4}} = 3.821, w_{m,\frac{3}{4}} = 3.383$ and $w_{M,\frac{3}{4}} = 4.538$ and the partition (Figure 9d)

$$
\begin{aligned}
&A_1^{3/4} = \{Zc, Zd, Ze\},\\
&A_2^{3/4} = \{T, U\},\\
&A_3^{3/4} = \varnothing,\\
&A_4^{3/4} = \{H, Y\},\\
&A_5^{3/4} = \varnothing,\\
&A_6^{3/4} = \{R, S\},\\
&A_7^{3/4} = \varnothing,\\
&A_8^{3/4} = \{M, V\},\\
&A_9^{3/4} = \{A - G, I - L, N - Q, W, X, Z - Zb, Zf\}.
\end{aligned}
$$

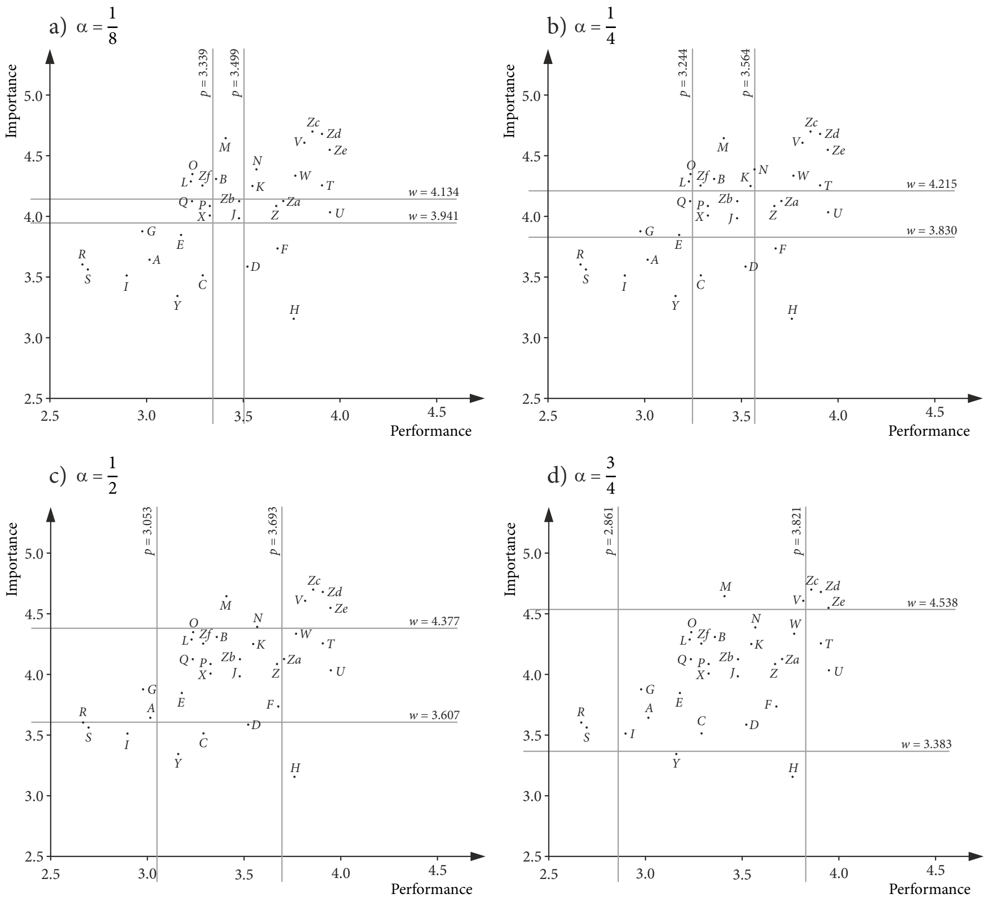

Figure 9. Nine categories for different confidence values (from a to d) (source: Lee et al., 2020 data)

The vast majority of attributes are in the *Grey zone* and only on three green practices, *Zc*, *Zd* and *Ze* (Figure 9d) an unambiguous decision (of *Competitive strength*) can be formulated.

By decreasing the confidence value to $\alpha = \frac{1}{4}$, near of the recommended confidence value $\alpha \approx 0.293$ (see the end of Section 3), we get the thresholding axes $p_{m,\frac{1}{4}} = 3.244$, $p_{M,\frac{1}{4}} = 3.564$, $w_{m,\frac{1}{4}} = 3.830$ and $w_{M,\frac{1}{4}} = 4.215$ (see Eqs (40)–(43)) and the partition

$$
\begin{aligned}
A_1^{1/4} &= \{N, T, V, W, Zc, Zd, Ze\},\\
A_2^{1/4} &= \{U, Z, Za\},\\
A_3^{1/4} &= \{F, H\},\\
A_4^{1/4} &= \{C, D\},\\
A_5^{1/4} &= \{A, I, R, S, Y\},\\
A_6^{1/4} &= \{E, G, Q\},\\
A_7^{1/4} &= \{L, O\},\\
A_8^{1/4} &= \{B, K, M, Zf\},\\
A_9^{1/4} &= \{J, P, X, Zb\}.
\end{aligned}
$$

The number of strategic activities positioned into an unambiguous category increase to 16 (*A*, *F*, *H*, *I*, *L*, *N*, *O*, *R*, *S*, *T*, *V*, *W*, *Y*, *Zc*, *Zd*, *Ze* – see Figure 9b). We can continue to increase the number of items associated with an unambiguous category by decreasing the confidence value. Indeed, by considering $\alpha = \frac{1}{8}$ and applying again Eqs (40)–(43) we obtain the thresholding axes as $p_{m,\frac{1}{8}} = 3.339$, $p_{M,\frac{1}{8}} = 3.499$, $w_{m,\frac{1}{8}} = 3.941$ and $w_{M,\frac{1}{8}} = 4.134$ and the partition (Figure 9a)

$$A_1^{1/8} = \{K, N, T, V, W, Zc, Zd, Ze\},$$
$$A_2^{1/8} = \{U, Z, Za\},$$
$$A_3^{1/8} = \{D, F, H\},$$
$$A_4^{1/8} = \varnothing,$$
$$A_5^{1/8} = \{A, C, E, G, I, R, S, Y\},$$
$$A_6^{1/8} = \{P, Q, X\},$$
$$A_7^{1/8} = \{L, O, Zf\},$$
$$A_8^{1/8} = \{B, M\},$$
$$A_9^{1/8} = \{J, Zb\}.$$

We get a clear decision on 22 items from 32 (Figure 9a), but, of course, we can continue to increase the number of strategic activities into $A_1^\alpha, A_3^\alpha, A_5^\alpha$ or A_7^α by decreasing the confidence value α. When $\alpha = 0$ we obtain a remarkable degeneration of the nine categories approach into four categories, namely standard importance-performance analysis represented in Figure 8.

In the sequel we illustrate the benefits of the proposed method based on the above results. The essential information to evaluate the problem under study is given by the attributes positioned in the quadrants A_1^α and A_7^α, *Competitive strength* and *Competitive vulnerability*. According with the results obtained in Lee et al. (2020) and represented in Figure 8, 11 items are included in the quadrant *Keep up the good work* (corresponding to *Competitive strength*). They are quite numerous, but some of them (at least *Z*, *Za* and *Zb*) are closed from the thresholding axes such that a clear decision is risky. By applying our proposed 9Qc-IPA method with a low confidence level $\alpha = \frac{1}{8}$ we obtain 8 attributes in quadrant *Competitive strength* (Figure 9d). We decrease the number of items placed in A_1^α by increasing the confidence value. Indeed, if $\alpha = \frac{1}{2}$ then four items are included in category *Competitive strength* (Figure 9c) and if $\alpha = \frac{3}{4}$ then only on three items the decision of *Keep up the good work* corresponding to *Competitive strength* should be recommended (see Figure 9d): *Zc Properly maintained grease traps*, *Zd Properly maintained kitchen hood ventilation system* and *Ze Properly cleaned and maintain dock areas.* As we can see (Figure 8), the attributes in the nearness of the thresholding axes in the standard IPA are successively eliminated and only the attributes *Zc*, *Zd* and *Ze* remain in the category of *Competitive strength* over a relatively high confidence level ($\alpha = \frac{3}{4}$). It is not at all surprising that the best performance-importance is obtained and must be maintained on attributes related to pollution prevention. As Dvorak state it (Dvorak, 2021, p. 1). "the pollution prevention approach was novel in focusing on increasing the efficiency of a process and reducing the amount of pollution generated at its source".

With respect to the quadrant A_7^{α} corresponding to *Competitive vulnerability* (or the category *Concentrate here* after the reduction to standard IPA) we obtain some interesting conclusions too. For example, according with Lee et al. (2020) seven items are placed in the category *Concentrate here* (Figure 8), namely *B*, *L*, *M*, *O*, *P*, *Q* and *Zf*, but four of them, *B*, *M*, *P* and *Q* are in the nearness of the thresholding axes. Again, it is not surprising that, according with 9Qc-IPA method, these are included in the category *Competitive vulnerability* under a very small confidence level, according with 9Qc-IPA method. If $\alpha = \frac{1}{4}$ then *L* and *O* are placed in the category of *Concentrate here* attributes (Figure 9b), if $\alpha = \frac{1}{8}$ then *Zf* get in this category, while *B*, *M*, *P* and *Q* are included in the ambiguous categories *Medium C* and *High B* (see Figure 9a). We conclude that managerial decisions related to the improvement on the attributes *L Energy efficient kitchen equipment such as ovens*, *holding boxes*, *steam tables*, *walk-in and reach-in refrigeration units*, *ice machine* and *O Energy efficient lighting in dining room*, *bar*, *restroom*, *lobby and outside areas* are recommended and the item *Zf Environment friendly fertilizers used in interior and exterior landscaping* should be careful treated too. We remark that by increasing again the confidence values ($\alpha = \frac{1}{2}$, as example – see Figure 9c) the category *Competitive vulnerability* becomes empty, that is does not exists an attribute with profound vulnerability in the problem under study.

Depending from the confidence value, the managers can gradually consider the strategic activities to focus on. We conclude that 9Qc-IPA method becomes a more accurate and useful tool in the hands of managers than the existing approaches in the importance-performance plane.

4.2. Example for financial performance evaluation

In the present section we analyze how our proposed 9Qc-IPA method refines the standard approach in the financial performance evaluation. The modifications of the results obtained with respect to different confidence values are highlighted too.

We have chosen another example from a different field to demonstrate the applicability of the method in various fields. We chose the study by Yang et al. (2018) in the field of financial performance, where 45 indicators were selected. Obviously, the field of financial performance is vast. The list of the 45 indicators taken as an example can be successfully completed according to the transition trends towards Low-Carbon Economy (Ionescu, 2020, 2021a, 2021b).

The financial performance and operating status of a power supply bureau are analyzed by the standard IPA model in Yang et al. (2018). The list of indicators together the synthetized results on a survey related with the importance and performance of indicators are given in Table 3.

Table 3. List of indicators and their performance and importance (source: Yang et al., 2018)

Indicator	p^j	w^j	Indicator	p^j	w^j
C1 Cost of power supply	1.0750	0.9808	C24 Quantity of electricity sale within the province	0.9762	1.0000
C2 Staff salary	1.0679	0.9135	C25 Debt structure	1.0000	0.6346
C3 Depreciation and amortization	0.9830	0.8526	C26 Short-term loans	1.0000	0.7051
C4 Controllable costs	1.1623	0.9712	C27 Medium and long-term loans	1.0000	0.7051
C5 Production and operation cost	1.1880	0.9103	C28 Current assets	0.9659	0.7724
C6 Customer service cost	1.2412	0.7821	C29 Monetary fund	0.9325	0.9968
C7 Auxiliary cost of production	1.0523	0.7724	C30 Power charge receivable	0.9434	0.9679
C8 Power purchase cost	0.9829	0.9519	C31 Inventories	1.0000	0.8814
C9 Line loss management	1.0171	0.9904	C32 Engineering materials	1.0000	0.7340
C10 Purchase price	0.9189	0.8974	C33 Intangible assets	0.9863	0.8846
C11 Quantity of electricity purchase	1.0081	0.9359	C34 Land	1.0000	0.9455
C12 Quantity of hydroelectric power	1.0457	0.6186	C35 Investment of informatization	0.9718	0.8878
C13 Quantity of renewable energy power	1.0283	0.5673	C36 Fixed assets	0.9842	0.9904
C14 Quantity of province electricity	0.9734	1.0000	C37 Assets received	0.9286	0.8237
C15 Other costs	0.9861	0.6763	C38 Community customer assets	0.9286	0.8686
C16 Income tax burden	1.0000	0.6282	C39 Power grid investment	0.9533	1.0000
C17 Giving guarantee	1.0000	0.7628	C40 Marketing technology reform	0.9621	0.9423
C18 Financial expense	0.9601	0.7436	C41 Production technology reform	0.8681	0.9423
C19 Interest expense	0.9601	0.7564	C42 Small infrastructure	0.9639	0.9071
C20 Regulated business income	0.9963	1.0000	C43 Main grid project	0.9877	1.0000
C21 Power price	1.0165	1.0000	C44 Distribution grid project	0.9813	1.0000
C22 Average unit price of electricity sold within the province	1.0165	1.0000	C45 Asset retirement	1.0000	0.7949
C23 Quantity of electricity sale	0.9762	1.0000			

Four groups of indicators are taken into account in the referred paper: *Cost control* (C1–C19); *Increase revenue* (C20–C24); *Optimization of liabilities* (C25–C27) and *Consolidation of assets* (C28–C45). Below we choose to apply 9Qc-IPA method to entire group of indicators, even if in Yang et al. they are separately treated.

We obtain

$\sum_{1\le j\le n} p^j / n = 0.9998, \sum_{1\le j\le n} w^j / n = 0.8688, \max_{1\le j\le n} p^j = 1.2412,\ \ \min_{1\le j\le n} p^j = 0.8681,$ $\max_{1\le j\le n} w^j = 1,\ \min_{1\le j\le n} w^j = 0.5673$ and according with Eqs (40)–(43) we get the thresholding axes in Table 4.

Table 4. Thresholding axes for different confidence values (source: Yang et al., 2018)

	$\alpha = \frac{1}{2}$	$\alpha = \frac{1}{4}$	$\alpha = \frac{1}{8}$
$p_{m,\alpha}$	0.9339	0.9669	0.9833
$p_{M,\alpha}$	1.1205	1.0601	1.0230
$w_{m,\alpha}$	0.7181	0.7934	0.8311
$w_{M,\alpha}$	0.9344	0.9016	0.8852

The corresponding partitions of the set of indicators determined by applying Eqs (31)–(39) are included in Table 5.

Table 5. Distribution of indicators into nine categories for various confidence values (source: Yang et al., 2018 data)

	$\alpha = \frac{1}{2}$	$\alpha = \frac{1}{4}$	$\alpha = \frac{1}{8}$
A_1^α	C4	C1, C2, C4, C5	C1, C2, C4, C5
A_2^α	C5, C6	∅	∅
A_3^α	∅	C6	C6, C7, C12
A_4^α	C12, C13, C15, C16, C25, C26, C27	C7, C12, C13, C15, C16, C17, C25, C26, C27, C32	C13, C15, C16, C17, C25, C26, C27, C32, C45
A_5^α	∅	C18, C19, C28	C18, C19, C28, C37
A_6^α	C10, C37, C38	C10, C37, C38	C3, C38
A_7^α	C29, C41	C29, C39, C40, C41, C42, C30	C8, C10, C14, C23, C24, C29, C30, C39, C40, C41, C42, C44, C35
A_8^α	C1, C8, C9, C14, C20, C21, C22, C23, C24, C30, C34, C36, C39, C40, C43, C44, C11	C8, C9, C11, C14, C20, C21, C22, C23, C24, C34, C36, C43, C44	C9, C11, C20, C21, C22, C34, C43, C36
A_9^α	C2, C3, C7, C17, C18, C19, C28, C31, C32, C33, C35, C42, C45	C3, C31, C33, C35, C45	C31, C33

We can draw several conclusions based on the distribution of the indicators as a result of applying 9Qc-IPA method. Firstly, as we already proved, the number of attributes placed in one of the unambiguous categories *Competitive strength-*A_1^{α}, *Irrelevant superiority-*A_3^{α}, *Relative indifference-*A_5^{α} and *Competitive vulnerability-*A_7^{α} decreases as the confidence value α increases. Indeed, the decreasing is significant, from 25 indicators for $\alpha = \frac{1}{8}$, to three indicators for $\alpha = \frac{1}{2}$. It is clear that urgent actions are required on C29-*Monetary fund* and C41-*Production technology reform*, because they already have a *Competitive vulnerability* for a high confidence value. Other indicators, C30-*Power charge receivable*, C39-*Power grid investment*, C40-*Marketing technology reform* and C42-*Small infrastructure* need attention because they are included in the category of *Competitive vulnerability* for lower levels of the confidence value. A circumspection must be had for some indicators such as C8, C10, C14, C23, C24, C35 and C44, that fall into the same category for a low level of the confidence value. On the other hand, the category of irrelevant superiority is of strategic importance in the evolution of a company. Often, huge resources are misdirected to improve indicators of minor relevance. Fortunately, according with the results in Table 5, the category of *Irrelevant superiority* is empty for the case into study, if the confidence value is high ($\alpha = \frac{1}{2}$). The indicator C6-*Customer service cost* falls into category of *Irrelevant superiority* for a confidence value $\alpha = \frac{1}{4}$ (close to our recommendation $\alpha \approx 0.293$), a sign that the performance is a bit disproportionately high relative to low importance on this indicator. From a managerial point of view, C7-*Auxiliary cost of production* and C12-*Quantity of hydroelectric power* must be kept under observation because, with a low confidence level ($\alpha = \frac{1}{8}$), they are placed into *Irrelevant superiority* category too.

Conclusions

Theorethical contribuțions

The theoretical contribution of this research is found in improving a diagnostic method, extremely used by theorists and practitioners. Business economic research continues to employ IPA without providing a mathematical rigorous founded method consistent with the new requirements of today's marketplace. Our study attempts to raise such an issue by proposing a new mathematical method to refine the current approaches to evaluating a set of attributes, indicators, or strategic activities into nine categories in the importance-performance plane. We propose a method, called 9Q-IPA, of the distribution of a set of attributes, indicators or strategic activities into nine categories in importance-performance plane. The method follows a valuable older idea, but it formalizes, for the first time according with our knowledge, the division of the set of attributes by determining four thresholding axes in importance-performance plane (two axes with respect to performance and two axes with respect to importance). Our method is inspired from classification theory, it is simple, rigorous and effective. The possibility to refines the standard IPA (which assumes only four categories) in different applications is open now. The benefits of the nine categories approach are significant in all cases, but especially when a large number of attributes is considered. The improved 9Qc-IPA method is obtained from 9Q-IPA method by introducing a confidence value in the determination of the thresholding axes.

Managerial implications

This method brings advantages to the management through its two essential characteristics: the safety given by the scientific rigor and the flexibility, by assuming the degree of risk desired by the management team. Also, by providing the two examples, the concrete application and benefits in relation to the IPA standard are presented.

9Q-IPA and 9Qc-IPA can be viewed as safer ways to get a good importance-performance analysis in the standard sense. By eliminating the ambiguous categories *Medium A*, *Low B*, *Medium C*, *High B* and *Grey zone* in the nine categories approach and by keeping the categories *Competitive strength* which can be associated with *Keep up the good work*, *Competitive vulnerability* which correspond to *Concentrate here*, *Relative indifference* which can be associated with *Low priority* and *Irrelevant superiority* which correspond to *Possible overkill*, we obtain a stronger standard IPA. The basis of the identification of improvement priorities and marketing strategies becomes more solid.

Our proposed method is tested and discussed on two sets of input data, already studied from the perspective of the standard IPA, related with the green practices in educational restaurant operations and the financial performance evaluation. The results highlight how the method allows a gradual approach that ensure the successful implementation of green practices in educational restaurants and focusing on indicators that improve the financial performance, respectively. On the basis of these applications, we can understand better how the distribution of attributes/indicators in quadrants is gradually changed together with the modification of the confidence level.

We conclude that 9Q-IPA method and 9Qc-IPA method proposed in the present paper formalize the nine categories analysis in the importance-performance plane, such that it becomes effective, easy applicable, refinement of the standard IPA and with sufficient elasticity at the disposal of the decision makers. The method become more elastic and it gives the possibility to take more or less risky decisions on attributes, according with the strategic development of the company and the skills of deciders.

One of the problems that management has to solve is the use of resources to improve consumer satisfaction and increase revenue. Prioritizing improvement measures is essential and the method we propose allows this. This is the essential benefit of our method to management, along with the scientific rigor of the method.

Limitations

As a limitation of the present research, we acknowledge that the 9Qc-IPA method could include reticence related to the comprehensive nature of the tool. For example, the data collection process for a performance indicator/index may impede organizations from using it. Nevertheless, for all that, some data scientists can build data-crunching machines with complex algorithms and to reports them in a comprehensive manner that can be understood by management in its entirety. Moreover, real-time analytics allow organizations to react without delay, get insights, and draw valuable conclusions immediately or rapidly after data entry into the databases. In this respect, we intend to collect data for different sizes of organizations and types of industries and to address the *strategic windows* performance-importance issue. Our subsequent research will further test the method using two waves of data collecting at two points in time.

Future research perspectives

We aim to apply the method to as many data as possible from different fields to check the applicability and ease of applying the method.

Conflicts of interest

The authors declare no conflicts of interest.

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Author contributions

O.B. and D.T. conceived the study and were responsible for the design and development of the data analysis. O.B, L.D. and E.B. were responsible for data collection and analysis. O.B. and L.D. were responsible for data interpretation. O.B., D.T. and E.B. revised the paper.

Disclosure statement

Authors do not have any competing financial, professional, or personal interests from other parties.

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