

Perceived export performance: A contingent measurement approach

Abstract: Despite considerable research on export performance, relatively little scholarly attention has been devoted to incorporating managers' perspectives into operationalizing this concept. This study proposes a new approach for measuring SMEs' export performance in the presence of multiple goals that are potentially conflicting, while accounting for different approaches to assessing export performance. Adopting a contingency approach, we develop two customized measures of perceived export performance: the individualized perceived export performance (IPEP) framework and the simplified model. We demonstrate the application of both measures based on a sample of 78 exporting SMEs in New Zealand, and compare the outcomes. The proposed frameworks are intended to measure export performance considering the specific priorities of managers, through explicit incorporation of manager- and firm-specific differences in the types and importance of goals, indicators, and benchmarks. This paper extends our understanding of export performance by proposing a more nuanced and holistic measurement approach that is tailored to individual firms and reflects firm-specific idiosyncrasies.

Keywords: perceived export performance, goal attainment model, contingency approach, analytic hierarchy process (AHP).

1. Introduction

More than four decades ago, Churchill (1979, p. 67) rightly noted that “researchers should have good reasons for proposing additional new measures given many are available”. This caution is particularly relevant for established topics such as export performance. Nevertheless, a careful review of the literature reveals that important limitations remain in the conceptualization and measurement of export performance. As Sousa et al. (2008, p. 2) noted, “the literature on export performance is probably one of the most widely researched and least understood areas of international marketing”. Reflecting on this, the aim of this paper is to provide a more nuanced understanding of subjective aspects of export performance assessment among SME managers, by developing an holistic measurement model that reflects firm-

specific individuality by explicitly accounting for managerial priorities in the evaluation of the firm's performance.

Despite promising developments in the literature (e.g., Diamantopoulos and Kakkos, 2007; Lages et al., 2005; Lages and Lages, 2004), it seems that academic research regarding the measurement of export performance has not kept pace with managers' evolving needs (Carneiro et al., 2016). One key limitation is that the literature has not really addressed the fundamental role of firm-specific idiosyncrasies in export performance evaluation. Managers' perceptions regarding performance create the basis for formulating important strategic decisions (Bourgeois, 1980; Morgan et al., 2004). However, previous studies have paid insufficient attention to incorporating managers' perspectives into operationalizing export performance. For instance, some of the widely-used measures of export performance, including EXPERF (Zou et al., 1998) and STEP (Lages and Lages, 2004), do not explicitly account for variation in managers' priorities and perceptions with respect to performance assessment. Reviewing the export performance literature, Katsikeas et al. (2000, p. 505) noted "a tendency to employ measures used by other researchers regardless of their applicability to the specific research design". More recently, Carneiro et al. (2016, p. 410) argued that

...most models of export performance have been developed from the (informed) minds of academicians, and [...] they have not, for the most part, been developed with the contributions of the practitioners in the beginning stages.

Export performance studies tend to include two implicit assumptions, which we argue are not fully aligned with what happens in practice. First, it is widely assumed that exporting firms have homogenous goals, and that they use the same benchmarks and indicators to evaluate their export performance. Under this assumption, export performance can be evaluated against predefined and uniform criteria. Second, the criteria that are selected by the researcher

are assumed to be relevant and appropriate for the respondent firm. However, several studies (e.g., Carneiro et al., 2016; Cavusgil and Zou, 1994; Diamantopoulos and Kakkos, 2007; Gerschewski and Xiao, 2015; Madsen, 1998) have questioned the validity of these assumptions. In their review of the organizational performance literature, Richard et al. (2009, p. 725) concluded: “We are making a quantum leap of faith in assuming that our measures relate to what the firm is seeking to achieve”. In a similar vein, Richard et al. (2009, p. 722) noted: “We may not be measuring the performance to which managers are managing”.

There is ample evidence that firms vary substantially, in terms of their exporting goals and the criteria and benchmarks that they employ for evaluating export performance (Diamantopoulos and Kakkos, 2007; Madsen, 1998). Reijonen and Komppula (2007) suggested that goals should shape the measures of success, on the basis that goals drive managerial attention and decision-making, and can influence individuals’ assessment of performance. As Beaver (2002, p. 98) maintained: “Perhaps the best and most accurate way to judge success is to ask whether the particular goals of the enterprise have been achieved”. In addition to exporting goals, performance indicators and benchmarks can also vary from one firm to another. Diamantopoulos and Kakkos (2007) argued that export performance needs to be measured with regard to differentially-weighted goals, and based on the specific benchmarks that managers consider in their export operations. Incorporating managerial perspective is particularly important when considering SMEs, which are typically characterized by highly-centralized and individualized leadership (Sadeghi et al., 2018).

An additional challenge in measuring export performance arises from its inherently paradoxical nature. Often, there are potential incompatibilities and trade-offs among different exporting goals, and an improvement in one indicator may come at the cost of another. For instance, if a firm’s strategy for a particular market is to gain a foothold and increase market share, strong financial results may not be realized immediately. This issue is especially salient

for SMEs, which operate under stronger resource constraints and are subject to more buffeting by external forces, relative to large firms; this creates the potential for more frequent re-assessment of realistic performance goals. What SME managers, especially in young firms, view as satisfactory performance may not appear to be very strong based on standardized measures.

Against this background, the purpose of this study is to develop a framework, using a contingency approach, for SME export performance measurement, addressing the multifaceted nature of the phenomenon and incorporating managers' perceptions and priorities. Under the assumption that export performance is idiosyncratic to the firm, its measurement needs to be dictated by the firm's specific strategic orientations and the rationales adopted by its managers. To reflect these differences in managerial judgment, the proposed framework employs a collection of criteria, indicators, and benchmarks pertaining to export goals, while accounting for variation in the value that managers attach to these aspects. To operationalize this framework, we introduce and elaborate on a novel methodology – fuzzy analytic hierarchy process (FAHP) – which is a powerful and flexible multi-criteria decision-making tool that is useful for handling complex problems. FAHP allows us to take into account, explicitly, the variation in managerial preferences with respect to the assessment of export performance. The use of fuzzy logic in conjunction with AHP facilitates the capture of the uncertainties and imprecision associated with managers' subjective performance assessment.

This study contributes to the conceptualization, operationalization, and discussion of export performance by proposing a comprehensive and contextualized means of measuring perceived export performance. Building on previous studies (e.g., Diamantopoulos and Kakkos, 2007; Lages et al., 2005; Lages and Lages, 2004), and adopting a contingency approach, we develop and test two approaches for measuring export performance: the “individualized perceived export performance” (IPEP) framework and a simplified model.

Both measurement approaches provide integrative, multidimensional conceptualizations of perceptual export performance, suited for different purposes. The more complex IPEP framework contributes to the export performance measurement literature by providing a systematic approach to (1) making sense of multiple – and potentially conflicting – perspectives associated with the assessment of export performance and enhancing the conceptual understanding of this complex phenomenon; (2) breaking export performance into finer elements (including different goals, criteria, benchmarks, and time frames) using a hierarchical structure; (3) eliciting managers’ judgments regarding the relative importance of these elements, while accounting for potential trade-offs and complementarities; (4) accounting for the subjectivity of judgments through the use of fuzzy logic; and (5) reaching a synthesized assessment by integrating variably-weighted components related to different aspects of export performance, using a systematic approach to calculating a representation of perceived performance. The IPEP framework provides a valuable managerial tool, but is overly complex for large-scale data collection; the streamlined simplified model aims to capture the essence of the IPEP in a form that is suitable for use in empirical research. In this way, our research aligns with calls in the literature for acknowledging and accounting for contextual nuances when investigating export performance (e.g., Chen et al., 2016; Diamantopoulos and Kakkos, 2007; Katsikeas et al., 2000; Sousa, 2004).

Reliable and valid measurement is critical to the development of usable research in any field (DeVellis, 2016). The proposed approach is intended to facilitate the alignment of export performance measurement with firm-specific business strategies, by providing insight into the question of how SME managers perceive and evaluate their firms’ export performance. Our approach is consistent with the recommendation of Hill and McGowan (1999, p. 9) that, when considering small businesses, “[the] researcher must represent or reconstruct the world as seen by others”. This is an important issue for studying the behavior of exporting firms, as the

conceptualization of export performance determines the relevance of both research questions posed and the comparability of findings. Closing the gap between managerial perceptions of export performance and academic measurement of this phenomenon is critical for establishing theory-driven knowledge and advancing our understanding of determinants and consequences of exporting.

2. Measuring export performance

Despite a substantial number of studies in this area, there is no single widely-accepted definition for export performance (Chen et al., 2016; Lages and Lages, 2004; Sousa, 2004). In this study, inspired by the definition of “subjective entrepreneurial success” provided by Wach et al. (2016), we define perceived export performance as *an individual’s understanding of the extent to which specific financial and non-financial goals of a firm are achieved in export markets, based on the criteria and benchmarks that are of importance to the manager.*

This definition provides a suitable point of departure for our consideration of export performance measurement for three reasons. First, it recognizes the role and nature of firm-specific idiosyncrasies in assessing export performance and underscores the importance of considering the goals, criteria, and benchmarks that are valued by managers. Second, by describing performance as the proximity between intended and attained exporting goals, this definition takes the role of export goals into account in an explicit manner; this allows us to go beyond the objective interpretation of outcomes and consider subjective evaluation and satisfaction with outcomes. Third, this definition accounts for both financial and non-financial aspects of export performance.

Some literature emphasizes that the perception of success is subject to managerial interpretation (Carneiro et al., 2016; Sadeghi, 2018). Madsen and Moen (2018) contend that managers’ overall satisfaction with exporting encapsulates all of the factors affecting firms’

operations. Therefore, the concept of managerial satisfaction is fundamentally important in capturing an evaluative judgment of export performance. We define managerial satisfaction as the outcome of the manager's comparison between the firm's actual exporting accomplishments and a set of prior expectations and goals.

Despite its importance, the notion of satisfaction has not been fully investigated in export performance research (see Diamantopoulos and Kakkos, 2007; Katsikeas et al., 2000). With some notable exceptions (e.g., Diamantopoulos and Kakkos, 2007; Sadeghi et al., 2018; Stoian et al., 2011), even in studies that have considered satisfaction, it has not tended to be operationalized relative to specific export goals (e.g., sales, profit market share), but rather considered at the broad level of "overall satisfaction" with export performance (e.g., Cavusgil and Zou, 1994; Zou et al., 1998). In addition, researchers have seldom provided details about the benchmark or time frame under consideration (Diamantopoulos and Kakkos, 2007; Katsikeas et al., 2000). This approach has been criticized on the basis that the question is overly broad, and the captured perception of performance can be formed by different implicit goals, criteria, and benchmarks considered by managers when indicating their satisfaction levels. The ensuing lack of consistency is problematic for comparing export performance across firms (Diamantopoulos and Kakkos, 2007; Madsen, 1998; Sadeghi et al., 2018).

One of the most comprehensive measures of subjective export performance is the assessed export performance (AEP) framework developed by Diamantopoulos and Kakkos (2007). The AEP offers a composite measure of export performance based on managers' perceived satisfaction as well as the importance of different export objectives (i.e., sales, profit, and new product introduction) with regard to two frames of reference (i.e., own plan versus competition). Still, the AEP framework has four key limitations: (1) the model considers a limited number of export objectives, (2) it does not incorporate a variety of indicators for measuring these goals and thus does not capture the differing export performance criteria that

are used by managers, (3) the conventional AHP approach used by Diamantopoulos and Kakkos (2007) has been criticized for failing to account for the inherent uncertainties and impreciseness associated with subjective judgments (see Kahraman et al., 2015), and (4) the role of different time-frames in assessing export performance is not reflected in the model. Although the AEP framework acknowledges the importance of timing in the assessment of export performance, time is placed at the lowest level of the performance assessment hierarchy, and only the relative emphasis that managers place on short- versus long-term perspectives is captured. Our premise is that this does not do full justice to the importance of time, especially for SMEs that are often subject to rapidly-changing strategies. Time is a defining contextual factor in export performance assessment, and the strategic orientations and priorities of managers are unlikely to remain constant across different timeframes. In this study, we extend the work of Diamantopoulos and Kakkos (2007), by proposing the IPEP framework that addresses the above limitations.

Consistent with both the extant literature (Hult et al., 2008; Katsikeas et al., 2000) and insights gleaned from interviews conducted as part of a larger research project¹, we posit that measuring export performance requires decisions about four sets of perspectives: level of analysis, type of performance, benchmarks employed, and mode of assessment. Below, we discuss each of these aspects, including some brief insights gained from the interviews².

2.1. Level of analysis

Export performance can be measured based on various organizational levels such as firm, country, market, export venture portfolio, and product line (see Diamantopoulos and Kakkos, 2007; Morgan et al., 2004). Despite these different levels, reviews of the literature show that

¹ We conducted interviews with 20 exporting SME managers in New Zealand. These interviews assisted us in mapping out key aspects of export performance, from the managerial perspective, specifically for SMEs.

² The detailed results of this qualitative research, based on semi-structured interviews, comprise a separate paper. We report some relevant findings here, to provide some practical insights into the issues.

studies have tended to use the firm as their level of analysis (see Hult et al., 2008; Katsikeas et al., 2000; Sousa, 2004). Some researchers argue that, while considering other levels may seem reasonable for larger organizations, the firm level is particularly relevant for SMEs, on the basis that their smaller size of operations means that other sub-levels may not provide meaningful insight into the firm's performance (Matthyssens and Pauwels, 1996; Oliveira and Cadogan, 2018). For example, Styles (1998, p. 27) argues that SMEs tend to use an aggregated evaluation at the firm level because "smaller firms are less able to isolate the performance of a specific export venture from total export performance, or even total firm performance". In contrast to this dominant view, some studies advocate for using more fine-grained levels of analysis such as export venture (Matthyssens and Pauwels, 1996; Morgan et al., 2004) or product-market export venture (Cavusgil and Zou, 1994).

All 20 of the SME managers that we interviewed reported evaluating aggregated export performance at the firm level, while also using finer levels of disaggregation, such as markets, for formulating action plans. In this study, following the prevailing approach in the literature, we adopt the firm as the level of analysis. However, the procedures that we introduce can equally be applied to measuring export performance at other levels of analysis.

2.2. Type of performance

Export performance measures can be categorized into two main types: financial and non-financial (Katsikeas et al., 2000; Sousa, 2004). Financial export performance is represented by indicators such as sales- profit-, and market share-related measures, whereas non-financial export performance is reflected by strategic measures such as the contribution of exporting to the reputation or positioning of the firm (Hult et al., 2008; Katsikeas et al., 2000; Sousa, 2004). Although there is evidence that firms generally pursue both economic and strategic goals in their foreign business, most extant studies focus primarily on financial goals, rather than the strategic aspect (Katsikeas et al., 2000; Madsen, 1998; Sadeghi et al., 2018). The lack of focus

on non-financial measures is especially striking in research on small firms, considering the evidence that SME owners often set non-financial goals for their businesses (e.g., Gray, 2002; Madsen and Moen, 2018; Wach et al., 2016; Wach et al., 2018). In our interviews, all of the SME managers reported adopting a combination of financial and non-financial measures for monitoring and assessing export performance. Furthermore, consistent with previous findings (e.g., DeTienne et al., 2008), we found that SME managers may persist with financial underperformance as long as they are satisfied with the attainment of specific non-financial goals. As one interviewee explained:

We are prepared to lose some money in the short run, and we see it as an investment, not as a financial loss. What we cannot afford is losing our reputation.

In this study, we argue that financial and non-financial aspects are complementary dimensions of export performance that need to be considered concurrently. Accordingly, we account for managerial perceptions of both importance and satisfaction with regard to traditional financial measures of export performance as well as a mix of non-financial measures.

2.3. Benchmark and time frame

Consistent with previous studies (Ambler and Kokkinaki, 1997; Carneiro et al., 2016), our discussions with SME managers revealed that they employ references when evaluating export performance, as it is more convenient for them to develop a relative assessment about their firm's performance, rather than an absolute judgment. Capturing export performance involves two categories of references: benchmarks and time frames (Madsen, 1998). According to Katsikeas et al. (2000), benchmarks and time frames are implicit or explicit referral sources and temporal horizons, respectively, against which performance is assessed. In this study, we incorporate three benchmarks (the firm's own plans, competitors' performance, and the

performance of the firm's domestic operations) and two time frames (short-term and long-term). From our interviews, we observed that managers' perceptions regarding achieved export performance differ considerably with the choice of benchmarks and time frame. In some cases, export performance was perceived positively against one benchmark (or time frame) and negatively against another; this demonstrates the importance of clarity with respect to frame of reference.

In this research, we ask respondents to indicate the relative importance of each of the three benchmarks (plans, competitors, and domestic performance) in assessing each criterion. This approach provides us with the ability to develop a weighted benchmark that can later be used in aggregating the results into an overall measure of satisfaction with performance. As for the time frame, we distinguish between short-term and long-term performance. Nearly all the SME managers interviewed reported using both short- and long-term export performance assessments, although their relative priorities varied in different time frames. Therefore, we consider short- and long-term export performance outcomes separately.

2.4. Mode of assessment: Objective vs. subjective measures of export performance

The literature has typically employed two different modes of assessment for capturing export performance: subjective and objective (Katsikeas et al., 2000). Objective or "hard" indicators measure export performance based on reported financial metrics. On the other hand, subjective indicators are judgmental and reflect the respondent's perceptions regarding performance, both financial and non-financial (Dess and Beard, 1984). Although objective measures may seem to be more reliable for evaluating export performance, previous research has shown that there are limitations associated with utilizing objective indicators, especially for SMEs, raising questions about their validity (e.g., Day and Wensley, 1988; Lages et al., 2005). Below, we discuss some of these limitations.

First, obtaining financial data can be extremely fraught, especially when dealing with smaller firms; secondary information on firms' export activities is seldom publicly available, and many privately-owned firms are reluctant to disclose financial information to researchers (Lages et al., 2005; Morgan et al., 2004). Second, even for publicly-listed firms, specific information related to export activities is not typically provided in financial reports (Katsikeas et al., 2000; Lages et al., 2005; Madsen, 1998). Third, performance evaluation is highly idiosyncratic, and firms often view export performance differently from one another. A financial outcome that is perceived as a success by one company can be a failure for another, or even for the same company under different conditions (Brouthers et al., 2009; Diamantopoulos and Kakkos, 2007). Fourth, the use of different accounting standards complicates the comparison of outcomes (Brouthers et al., 2009; Hult et al., 2008; Lages et al., 2005).

Subjective measures of export performance seem to be particularly relevant for SMEs. There is evidence that SME managers tend to rely heavily on perceptions of export performance when making decisions and formulating actions (e.g., Carneiro et al., 2016; Madsen and Moen, 2018; Sadeghi et al., 2018). In addition, subjective measures are viewed as strong indicators of the extent to which the firm has exploited the available export opportunities and been successful in its chosen export strategy (Cavusgil and Zou, 1994; Lages and Lages, 2004). Finally, several studies have found that subjective and objective measures are highly correlated (e.g., Dess and Robinson, 1984; Venkatraman and Ramanujam, 1987).

The SME managers with whom we spoke were cognizant of the limitations of objective measures and showed a clear inclination toward evaluating export performance based on their own perceptions and interpretations. As one manager commented:

You cannot only rely on accounting measures for assessing the firm's outcomes. If not used properly, they can be misleading [...] these numbers are only meaningful when they are seen in the unique context of the firm.

Subjective measures are particularly applicable for the context of our research, as our aim is to investigate managers' perceptions and the value that they place on different aspects of export performance. As concluded by Hult et al. (2008, p. 1071), "The use of primary data for measuring performance in IB is particularly appropriate when the researcher is aiming to identify not only the goals associated with a specific strategy but also the understanding and interpretation of an organization's performance goals by managers".

3. A contingency approach to perceived export performance measurement

This study is based on a contingency approach, consistent with the argument by Paul et al. (2017, p. 337), that "exporting and SME internationalization are outcomes of their strategic choices made in contextual settings". Following Cavusgil and Zou (1994), exporting can be seen as a strategic response to the interplay of internal and external forces. This implies that expectations from exporting are likely to vary among firms that are dealing with different internal and external conditions and, therefore, different firms will view some goals as being more important than others (Diamantopoulos and Kakkos, 2007; Gerschewski and Xiao, 2015).

The contingency approach provides a suitable basis for contextualizing export performance. According to this perspective, the most appropriate measure of performance for each firm is the one that best fits the particular contingencies of that firm (Jääskeläinen et al., 2012; Rejc, 2004). The use of the contingency approach for measuring export performance is in line with the conclusion of Katsikeas et al. (2000, p. 505) that:

the choice of export performance measurement approach depends on contextual factors [...] This implies the need for the adoption of a contingency approach in

the selection of individual export performance measures to address the idiosyncrasies of the situation at hand, rather than taking a dogmatic view.

In addition, this study draws on the rational goal or goal attainment model (Etzioni, 1964; Price, 1968), which provides a theoretical underpinning for measuring export performance. This model assumes that decision makers are rational and capable of setting goals, and a firm's performance can be evaluated in terms of the extent to which it accomplishes those goals; therefore, the focus is "exclusively on the ends", which is the achievement of goals (Henri, 2004, p. 98). From the perspective of the rational goal model, the most appropriate performance measures are those linked to the organization's plans, goals, and objectives (Aliasghar et al., 2019a; Matthews, 2015). Accordingly, when assessing performance, managers should answer this question: "Given our mission, how is our performance going to be defined?" (Magretta and Stone, 2002, p. 129). In this approach, performance is assessed based on the degree to which the specific predetermined goals of an organization have been realized. An important element in measuring performance using this approach is thus managers' level of satisfaction with the attainment of goals, where satisfaction is defined as the proximity between actual and desired outcomes or objectives (Ambler and Kokkinaki, 1997). This perspective is consistent with Ambler and Kokkinaki (1997, p. 668), who concluded that "performance should be measured against the performer's own plan".

On this basis, we propose that, in order to capture the full essence of manager-perceived export performance, researchers need to address four questions that are specific to each firm:

- 1- What are the goals against which the manager evaluates export performance, and what is the relative importance of each of these goals?
- 2- What are the indicators through which the manager evaluates the attainment of each exporting goal, and what is the relative importance of each of these indicators?

- 3- What are the benchmarks against which the manager evaluates export performance, and what is the relative importance of each benchmark for assessing each indicator?
- 4- To what extent the manager is satisfied with the actual attained outcomes, based on each indicator and each benchmark?

The first three aspects pertain to what export performance means to an individual, and capture the manager's perceptual patterns based on the firm's differentially-weighted goals and the weighted criteria and benchmarks that a manager employs to evaluate performance. The last question concerns the degree of satisfaction resulting from the achieved outcome.

It is worth mentioning that the level of satisfaction, *per se*, does not fully capture perceived export performance, as it does not necessarily reflect the manager's strategic orientation in individual exporting markets. Satisfaction based on achieving an unimportant goal may not imply success. By the same token, dissatisfaction with underperforming relative to an unimportant goal may not be an indicator of failure. Therefore, it is important to incorporate the notion of "relative importance", to avoid over- or under-estimation of export performance (Diamantopoulos and Kakkos, 2007).

Export performance is inherently a complex and multi-level phenomenon (Oliveira and Cadogan, 2018). The numerous combinations of goals, criteria, and benchmarks, each with varying importance, reflect the many alternative ways in which managers may evaluate export performance. This heterogeneity poses a methodological challenge for measurement. In this study, we propose a multi-criteria decision-making (MCDM) method to address the aforementioned four aspects in measuring manager-perceived export performance and to integrate these elements in a systematic manner.

4. Method

MCDM techniques are suitable for developing decision support systems for addressing complex and multifaceted problems that involve multiple influences and goals that may conflict with each other (Kahraman et al., 2015; Sadeghi, 2018). In this study, we employ a fuzzy extension of analytic hierarchy process (AHP), a widely-utilized MCDM approach, to capture the judgments of managers and assess the relative emphases that they place on various aspects of export performance.

4.1. *The analytic hierarchy process*

AHP was developed by Saaty (1980) as a tool for prioritizing alternatives in the presence of multiple, and potentially-conflicting, criteria. In complex problems, decision makers cannot intuitively assess and synthesize the multiple aspects that are involved (Forman and Gass, 2001; Sadeghi, 2018). AHP can help the decision maker to account for multiple constraints and find a way to make rational compromises. This approach facilitates the finding of a solution that addresses the decision maker's specific goals and priorities and is consistent with his/her understanding of the problem. The key is that importance weights are not assigned arbitrarily; rather, the priorities are derived from the decision maker's judgments. A key advantage of AHP lies in its ability to incorporate subjective and intangible criteria that, while challenging to measure, are often critically-important aspects of decision-making. As noted by Dyer and Forman (1991, p. 75): "AHP allows decision makers to set priorities and make choices on the basis of their objectives and knowledge and experiences in a way that is consistent with their intuitive thought process".

AHP analysis is based on three key principles: decomposition, comparative judgment, and synthesis of priorities (Saaty, 1980). In the decomposition stage, the problem is modeled as a hierarchy of goals, criteria, and possible alternatives, similar to a decision tree. After decomposition of the problem and establishment of the hierarchy, the relative importance of

each of the elements in each level of the hierarchy (the “local weight”) is assessed. In this comparative judgment stage, decision makers are asked to assess the relative importance of the elements at each level, through pairwise comparisons; these are “local priorities”. In the third stage, the local priorities are synthesized to generate the global or composite index.

4.2. *The fuzzy analytic hierarchy process (FAHP)*

Assessing relative importance through pairwise comparison involves a considerable amount of subjective judgment. As noted by Chen et al. (2011, p. 266), “The decision maker may be subjective and uncertain about the level of preference due to incomplete information or knowledge, inherent complexity and uncertainty within the decision environment”. The conventional AHP approach has been criticized for failing to take into account some of the uncertainties that are inherent in many real-world decisions (Kahraman et al., 2015). In conventional AHP, respondents are asked to assess the relative importance of pairs of elements at the same level of the decision-making hierarchy using a nine-point rating scale. Despite the benefits of ease of use and simplicity, the discrete values used for the pairwise comparisons may not fully reflect the imprecision associated with human judgment (Mardani et al., 2015). In response, a “fuzzy” extension of AHP has been suggested (e.g., Buckley, 1985; Chang, 1996). Fuzzy set theory was introduced by Zadeh (1965) for modeling uncertainty in decision making. Rather than employing rigid values, fuzzy set theory employs assessment based on linguistic terms, which can then be quantified according to fuzzy logic.

Fuzzy AHP (FAHP) deals with uncertainties in evaluation by asking decision makers to express their judgments using linguistic terms, such as “weakly more important” or “strongly more important”. FAHP converts these linguistic data into “fuzzy numbers” and uses them to derive the respondent’s relative weights for various decision criteria. Several FAHP methods have been proposed; for a review, see Kahraman et al. (2015). In this paper, we adopt the extent analysis method proposed by Chang (1996), a commonly-used approach that has been applied

successfully in many fields (Kubler et al., 2016; Larimian et al., 2013; Sadeghi, 2018). Triangular fuzzy numbers (TFNs) are used to represent the linguistically-expressed pairwise comparisons; see the Online Appendix for the TFN definitions and the analytical details. While FAHP has been applied to problems such as supplier choice, project selection, and market segmentation (see Mardani et al. (2015) and Kahraman et al. (2015) for reviews), this research represents, to the best of our knowledge, the first attempt to apply the method to the assessment of export performance.

5. Proposed fuzzy AHP model: The IPEP framework

This paper proposes an individualized perceived export performance (IPEP) framework that allows for the consideration of inter-firm differences in export performance assessment. In this section, we explain the analytical procedure of measuring export performance using the IPEP framework and demonstrate its use with data collected from an exporting firm in New Zealand. This sample case is a seafood producer and exporter that was established in 2009 and started exporting from 2010. It has 55 employees and is currently exporting to eight foreign markets.

The IPEP approach is comprised of six distinct, but inter-related, steps, as shown in Figure 1. In the first two steps, we represent the managerial perception of export performance using a hierarchical framework. The coarsest level addresses the main exporting goals: financial and non-financial. The next level includes three financial sub-goals (sales, profit, and market share), as well as one non-financial sub-goal (strategic). Each of the four sub-goals has associated indicators for assessing the firm's performance (e.g., export sales ratio, export sales growth, and export sales volume, under the sub-goal of sales), and three benchmarks (the firm's own plan, competitors, and domestic performance) are associated with each indicator. The full hierarchical framework is presented in Figure 2.

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The measures used to develop this export performance framework are based on an analysis of prior research, along with insights gained from the interviews with 20 exporting SME managers. The three financial sub-goals and their corresponding indicators are consistent with the Katsikeas et al. (2000) and Sousa (2004) categorizations of export performance measures. The indicators pertaining to the non-financial sub-goals are adopted from Katsikeas et al. (2000), Brouthers et al. (2009), Sousa (2004), and Papadopoulos and Martín Martín (2010).

The third step of the IPEP approach involves the administration of a pairwise comparison questionnaire to collect information pertaining to each manager's perceptions regarding the relative emphases that they place on the goals, sub-goals, indicators, and benchmarks. (A sample of questions from the survey instrument is presented in Appendix A.) This step involves conducting a series of pairwise comparisons across all of the possible combinations of elements in each level of the IPEP framework's hierarchy. For example, to obtain the relative importance of the three sales-related indicators, we asked managers to conduct pairwise comparisons for the three pairs of indicators.

In the FAHP approach, the relative weights (representing importance) of the elements of each level of the hierarchy are called "local weights". The extent analysis method proposed by Chang (1996) is utilized to calculate the local weights of the goals, sub-goals, indicators, and benchmarks. In this method, decision makers are asked to express their pairwise comparisons using linguistic variables such as "weakly more important" or "strongly more important". These linguistic assessments are converted into a set of triangular fuzzy numbers (TFNs),

which are the most widely-used form of fuzzy numbers (Kahraman et al., 2015). A TFN is defined by three real numbers expressed as (l, m, u) , where l and u are minimum and maximum possible values and m represents the most likely value that describes a fuzzy event (Zadeh, 1965). Details about the definition of triangular fuzzy numbers and Chang's extent analysis method are provided in the Online Appendix. Following Chen et al. (2014), we used the values shown in Table 1 to convert linguistic judgments to triangular fuzzy numbers. For example, if a participant considers element i to be "fairly more important" than element j , the pairwise comparison between i and j is represented as $a_{ij} = (\frac{3}{2}, 3, \frac{9}{2})$.

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Insert Table 1 about here
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For example, for the sample firm, the linguistic data collected by the pairwise comparison questionnaire were converted into corresponding triangular fuzzy numbers (per Table 1) and used as inputs for the Chang (1996) extent analysis, to calculate the local weights for each element in the framework. The local weights for the goals, sub-goals, indicators, and benchmarks are presented in Table 2. These figures reflect the relative degree of importance of the elements within a group. For example, the local weight associated with export sales ratio (.184) represents the relative importance of this indicator compared to the other two indicators under the sales-related sub-goal (i.e., export sales growth and volume). The local weights associated with the elements within each such group sum to one; e.g., for the three indicators under the sales-related sub-goal (i.e., export sales ratio, growth, and volume), $.184 + .338 + .478 = 1$.

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Insert Table 2 about here
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Step 4 involves the calculation, for each of the indicators, of global (overall) weights associated with the three benchmarks. This is accomplished by multiplying the local weight for each benchmark by the local weights of each of the associated higher-level elements (i.e., indicator, sub-goal, and goal). For the sample firm, the calculated global weights associated with the three benchmarks for each of the 13 indicators are shown in Table 2. These values represent the overall importance of the 39 indicator-benchmark pairings. For example, based on this table, “export sales profitability” based on “own plans” is the most important indicator-benchmark pairing (.070, in the fifth column). The global weights for the 39 benchmarks sum to one.

In the fifth step, managers are asked to identify their level of satisfaction with their firms’ attained performance, based on each of the 39 indicator-benchmark combinations (13 indicators, with three benchmarks each), using a seven-point Likert scale (1 = “not at all satisfied,” and 7 = “very satisfied”). The second-to-last column in Table 2 shows the sample firm manager’s reported level of satisfaction with the attainment of objectives, with respect to each indicator-benchmark pair.

Finally, in the sixth step, the outputs of FAHP (the global weights associated with the indicator-benchmark combinations calculated in step 4) are combined with the satisfaction ratings from step 5, to compute the weighted managerial satisfaction index. The overall individual perceived export performance index (the IPEP index) can then be calculated by summing up the values of the weighted satisfactions measured in the previous step across all of the benchmarks.

The last column of Table 2 shows the weighted satisfaction scores for the sample firm. These scores are obtained by multiplying the level of satisfaction for each indicator-benchmark pair by its corresponding global weight of benchmarks. The aggregated weighted satisfaction

scores for each of the main goals (financial and non-financial) can then be calculated by summing the corresponding values across the associated benchmarks. For the sample exporting firm, these results are shown in Table 3. Lastly, the overall combined IPEP index can be obtained by summing the values across each row of Table 3.

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Insert Table 3 about here
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6. Simplified method

The IPEP framework’s extreme level of detail in capturing the priorities of managers for export performance evaluation comes at the cost of complexity in terms of data collection and analytic procedures. Moreover, implementing this framework requires the administration of a long questionnaire that takes up a great deal managerial time. This, in turn, may result in a lower response rate. To address these issues, building on the existing literature and results of our pilot tests, we propose a simplified model. While retaining the key benefits associated with the IPEP framework, the simplified model offers a more parsimonious approach for measuring export performance that is more accessible and easier to implement for empirical studies.

The proposed simplified model of perceived export performance measurement is essentially based on the idea of weighted satisfaction underlying in the IPEP approach. This streamlined model attempts to account for the two fundamental building blocks of the IPEP framework: level of importance and level of satisfaction with respect to the performance indicators.

In this approach, similar to the IPEP framework, export performance is measured based on three financial, and five non-financial, indicators. We asked the respondents to indicate both the level of importance of each performance indicator and the extent to which they are satisfied with the attainment of export objectives with respect to each performance indicator, using seven-point Likert scales. To further simplify the model, respondents were asked to conduct

all of the evaluations with respect to the benchmark that they use most often. Similar to the IPEP questionnaire, these questions were asked with respect to both short-term (most recent financial year) and long-term perspectives (the past five financial years). Finally, export performance measures were calculated by multiplying the perceived level of importance by the level of satisfaction for each indicator.

Our approach is in line with the recommendation by Hitt (1988, p. 30) that, “The criteria/measures used to indicate performance in an effectiveness domain must be weighted and combined into some overall model”. A similar weighting approach for performance measurement has been used in previous studies (e.g., Gerschewski et al., 2015; Sadeghi et al., 2018). Our study advances this approach by including more comprehensive sets of financial and non-financial indicators and accounting for the preferred benchmark for each respondent. Our approach in developing a broad measure of export performance in the simplified model resonates with Carneiro et al.’s (2016, p. 416) argument that “Forgoing a broader conceptualization of export performance may sacrifice content validity, but that does not mean that it would necessarily violate content adequacy –as long as the relevant performance perspectives are still retained”.

The IPEP framework and the simplified model are useful for different purposes. The IPEP framework presents a detailed measure that can be used as a practical decision support tool for planning and monitoring a firm’s export activities. The simplified model is more parsimonious and provides a broad conceptualization of export performance that captures the key aspects of this construct in a more convenient way. This model is suitable for the purpose of empirical studies, as it is easier to implement and requires considerably shorter data collection time. A brief comparison of these two methods is provided in Table 4.

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Insert Table 4 about here

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7. Sample and data collection

In this section, we illustrate the application of the IPEP framework and the simplified method using survey data collected from a sample of exporting SMEs in New Zealand. Following the definition of SMEs provided by the New Zealand Ministry of Business, Innovation & Employment (MBIE, 2014), we focus on firms with 100 or fewer full-time employees. Firms operating in both the service and manufacturing sectors, from low- and high-tech industries, are included in the study. Some representative industries include agriculture, beverage, winemaking, industrial equipment, natural health, education, and biotechnology. Employing a multi-industry sample provides broader coverage and more variation in the responses, and thus offers the potential for greater generalizability (Morgan et al., 2004).

After identifying potential companies to participate in the study, we mailed a questionnaire with a postage-paid reply envelope to the company's official postal address, inviting the senior managers or export managers to participate in this study. These respondents are likely to have the in-depth knowledge required to provide useful and accurate information about the international activities of their firms. Email and telephone follow-ups were also undertaken. Respondents were asked to complete a survey instrument that included questions associated with both the IPEP and simplified methods. In order to understand the differences between managers' shorter- and longer-term perspectives, respondents were asked to provide their assessments pertaining to both the most recent financial year and the period comprising the past five financial years. Altogether, we contacted 520 companies. Of these, 78 returned fully-completed and usable questionnaires, resulting in a response rate of 15.56%; 79% of our sample had fewer than 19 employees and 71% of them obtained less than half of their total sales from foreign markets. The sample mean age of these firms was 11.8 years, and they had

been in international markets for 3.2 years, on average, at the time of data collection. As such, our sample is comprised of rather small firms (which is typical for New Zealand) and young firms with often-limited international experience.

8. Results

8.1. Results of implementing the IPEP Framework

For each firm, we undertook the procedure outlined previously to analyze the responses, and to calculate the local and global priorities of the elements at each level of the hierarchy. These priorities were calculated separately for shorter- and longer-term perspectives. An overview of the variation in the relative importance of the goals, sub-goals, and indicators across the 78 firms in the sample is provided in Figures 3 (short-term) and 4 (long-term). These results suggest that there is a substantial variation across the sample firms in terms of the relative emphasis that the respondents placed on the different aspects of export performance in their assessments. This variation reinforces the view that export performance is a complex and multifaceted phenomenon that is idiosyncratic to the firm, along with the importance of explicitly accounting for the values that managers attach to different aspects of export performance in their assessments.

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Insert Figure 3 about here

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Insert Figure 4 about here

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We analyzed the variation in participants' responses using one-way analysis of variance (ANOVA) to assess whether there are significant differences among the average perceived importance of the three benchmarks across the export performance criteria; see Table 5. For all of the export performance criteria, both short- and long-term, there are significant differences ($p < .001$) in the benchmarks' mean levels of importance. More specifically, the sample firms

tend to place significantly more importance on “own plan”, relative to the other two benchmarks. Also, “competitor's performance” is found to be significantly more important as a benchmark, on average, compared to “domestic performance”.

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Insert Table 5 about here
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8.2. Results of implementing the simplified method

In order to illustrate the feasibility of the proposed simplified model and examine its usefulness, we compared the paired results of responses for the IPEP and the simplified approaches for both the short- and long-term perspectives. Table 6 shows the simplified model’s measurement variables, exploratory factor analysis (EFA) component loadings, percentage of variance explained, and internal reliabilities. The EFA results revealed that financial and non-financial measures load onto two distinct factors for both time frames. In addition, the Cronbach’s alphas of all constructs exceed the .6 threshold value (Bagozzi and Yi, 1988), which indicates acceptable internal reliability in this exploratory study. Finally, we utilized the EFA component loadings as weights in calculating combined factor scores to represent the overall financial and non-financial export performance for each participant.

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Insert Table 6 about here
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8.3. Comparing the results of the IPEP Framework and the simplified method

We assessed the agreement between the results obtained from the IPEP and simplified methods. Following the guideline outlined by Linnet (1993), we regressed the standardized values of the IPEP results on the results from the simplified model, using ordinary least squares, to check for systematic differences between the two methods. In this approach, the two methods are judged to provide similar results if the estimated regression line does not deviate significantly from the equity line (a slope of 1 and an intercept of 0). The results show that, for financial and non-financial responses, both short- and long-term, neither the slope nor intercept of the estimated regression line differs significantly from those of the equity line, with at least

95% confidence, providing support for the notion that the two methods produce substantially similar results. Figure 5 provides a graphical representation of the results obtained from the two methods, with the outcomes obtained from the simplified approach plotted against the mean-centered results obtained from the IPEP framework.

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Insert Figure 5 about here
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9. Discussion and conclusion

Existing measures of export performance are typically based on a set of predefined variables and weightings that are treated as identical for all firms (e.g., Lages and Lages, 2004; Zou et al., 1998). The lack of attention to managers' perceptions, preferences, and goals has been criticized in previous studies. For example, Katsikeas et al. (2016, p. 11) conclude that ignoring managers' views "forces researchers to either assume (implicitly or explicitly) what firms' goals might be or to adopt more "goal-agnostic" financial-market performance measures" and argue that this approach may lead to inaccurate and misleading results.

In this article, we argue that, when it comes to export performance assessment, one size does not fit all. In line with previous studies (e.g., Carneiro et al., 2016; Madsen, 1998), we find evidence that managers hold multi-faceted views of export performance in terms of goals, criteria, and benchmarks, and place different values on these aspects. Not only do managers' perceptions of export performance vary among firms, but also within-firm perceptions may change over time. Therefore, the use of a uniform approach may lead to a mismatch between measured export performance and the manager's perception of this phenomenon. For example, profitability may not be the most appropriate measure for capturing the export performance of a firm that is pursuing another goal (e.g., market share growth), and measures that are applicable for large or established firms may be much less so for younger SMEs that are early in their export activities. While a manager might consider the firm to be successful, based on

the achievement of firm-specific goals, assessment using a different set of researcher-chosen indicators could yield a misleading result. This mismatch in the treatment of export performance impedes the generation of reliable knowledge and may be a key reason behind the often-mixed results in the current literature. Given these misalignments, it is not surprising that managers may find traditional export performance measures irrelevant to their operations (Alteren and Tudoran, 2016).

Improving the effectiveness of export performance measurement is fundamental to advancing the international marketing literature. In this paper, we contribute to this advancement in three ways. First, our approach offers a clearer understanding of the constituent elements of perceived export performance, by unpacking this construct and developing an inclusive measure that explicitly captures its multidimensionality. Although the separate components of our proposed measure have previously been utilized on an individual basis, our study is among the few to use them collectively and to systematically integrate them in a sequential manner. Second, we respond to calls for adopting an holistic view to measuring export performance and accounting for the inherently cognitive nature of the phenomenon (e.g., Chen et al., 2016; Diamantopoulos and Kakkos, 2007; Katsikeas et al., 2000; Morgan et al., 2004; Sousa, 2004). We do so by adopting a contingency approach and offering a detailed and comprehensive measurement framework that systematically captures perceived export performance based on what is valued by individual managers. Third, our data demonstrated considerable heterogeneity in managers' strategic priorities with respect to assessing export performance. The proposed approach in this study seeks to reflect these heterogeneities and reduce the gap between academic research and business practice by tailoring the measurement to each individual firm. Our approach is in line with Katsikeas et al. (2000, p. 506), who wrote: "The contingency element inherent in export performance measurement suggests that choice of measure depends on firm-specific conditions".

The IPEP framework proposed in this study can be viewed as an extension of the AEP framework developed by Diamantopoulos and Kakkos (2007), with four key improvements. First, we extend the AEP by proposing a more fine-grained and comprehensive hierarchy of goals, criteria, and indicators, to more closely reflect managerial export performance assessment. Second, the IPEP framework reflects the uncertainties associated with subjective judgments by adopting fuzzy logic that allows for a more realistic representation of managerial judgment. Third, the IPEP framework considers the short- and long-term separately, acknowledging different goals measures export performance with regard to the short- and long-term separately, and captures the weight of all elements (including goals, sub-goals, indicators, and benchmarks) for the specific timeframe. Fourth, recognizing that the extreme level of detail of the IPEP framework for capturing managers' priorities comes at the cost of complexity in data collection and analysis, we build on the idea of "weighted satisfaction" that underlies the IPEP approach and develop a simplified model for measuring export performance that is more parsimonious and easier to implement for empirical research while retaining the key benefits associated with the IPEP approach.

We have demonstrated the feasibility of both the IPEP framework and the simplified model empirically, based on a sample of 78 exporting SMEs in New Zealand. The data reflect considerable variation in the importance that the respondents attach to different elements of export performance. This reinforces the notion that export performance is idiosyncratic to the firm and that its measurement should be dictated by the firm's specific strategic orientations. Furthermore, our comparative analysis offers preliminary evidence that the two methods produce similar results, providing confidence that the simplified method, which represents a substantial reduction in the time required to complete the questionnaire, also generates a good approximation of perceived export performance with only limited loss of data richness.

Our use of fuzzy AHP for the IPEP framework, to decompose the multi-attribute problem and capture managerial preferences, represents an important contribution. Fuzzy AHP allows us to retain, explore, and account for variation in managerial preferences with respect to export performance assessment while allowing the respondent to focus on one pair of factors at a time, rather than having to deal with the entire complex system. Managerial assessment of export performance is fraught with uncertainty and imprecision that is difficult to represent adequately in a fully deterministic manner. Adopting fuzzy logic in our framework enables us to incorporate some of the uncertainties in managers' real-world judgments through the use of linguistic variables to express the evaluations.

Our proposed approach for measuring export performance relies heavily on the respondent's judgments and personal interpretations. Previous studies have argued that the results obtained by such subjective, self-report performance measures are prone to cognitive biases, which may lead to under- or over-estimations of performance (Lages et al., 2005; Richard et al., 2009). While we acknowledge the potential for self-assessment bias in subjective performance assessment, this is not of great concern in the context of this study. The purpose of our proposed approach is not to investigate how managers *should* evaluate the performance of their firms' exporting operations. Rather, we aim to take a realistic look at managerial practices and map out managers' *actual* perceptions of the assessment of export performance. Managers' perceptions of performance drive their behavior, decision making, and strategy development (Angel et al., 2018; Madsen and Moen, 2018). Therefore, rather than trying to reduce or eliminate the impact of individual bias in performance assessment, we attempt to capture it and reflect it in the proposed measurement. The role of subjective judgments in shaping firm strategy is particularly salient for SMEs, which are typically governed by rather centralized management processes that rely on the championing manager for formulating strategies and making key decisions. By preserving the individuality of firms in the process of export

performance measurement, the proposed frameworks allow for a more meaningful inter-firm comparison in the presence of multiple goals and different modes of assessment.

9.1. Managerial Relevance

Our study has several implications for managers of exporting SMEs. The IPEP measurement approach proposed in this study is a versatile tool that can help managers to develop a clearer understanding of the constituent elements of export performance. It can also assist SME managers in their efforts to track the process of their exporting operations and assess their performance, while shedding light on the trade-offs associated with pursuing different goals. There is evidence that managers prefer to use customized performance measures that are aligned with their strategic priorities, rather than employing generic measurement models (e.g., Banker et al., 2004; Lipe and Salterio, 2000); the IPEP framework offers a deeply firm-specific approach. In addition, alignment between performance measures and strategic goals is expected to be positively related to the firm's performance (e.g., Clark and Ambler, 2001; Lingle and Schiemann, 1996; Pinto and Curto, 2007). The IPEP framework provides managers with a systematic decision support tool that is tailored to their changing goals and priorities. This holistic approach to export performance measurement facilitates the process of monitoring and managing export operations by simultaneously accounting for multiple aspects.

9.2. Limitations and future research

The IPEP framework is not intended to be a silver bullet to overcome the multiple and durable challenges raised in the literature. Rather, contributes toward advancing the literature by proposing a fine-grained and customized measure of perceived export performance that more closely reflects individual managers' preferences. The measurement approach proposed in this study has some limitations, which may point to opportunities for future research.

First, it is important to note that the appropriateness of a performance measurement approach depends on its compatibility with a study's theoretical foundation. Our subjective framework may be particularly useful for measuring export performance in studies that are grounded in behavioral theory (Cyert and March, 1963) or related perspectives such as organizational learning (Levitt and March, 1988). For instance, studying the behavior and development process of exporting SMEs from an organizational learning perspective may require incorporation of key managers' priorities and orientations, making a subjective measure particularly appropriate. On the other hand, a subjective performance measure may be less appropriate if the focus of the research is more on outcomes than processes. For example, when considering performance from a stakeholder perspective (Freeman, 2010), relying solely on managers' perceptions may not be justified. This theoretical perspective necessitates the use of beneficiary-centered measures that explicitly address the interests of stakeholders (such as suppliers, government, environment, and society); such research is better suited to the use of more outcome-focused and objective performance measures.

Second, despite our attempt to consider a wide range of factors in measuring export performance, the IPEP framework may not encompass a fully exhaustive collection of criteria. Future studies may seek to modify this framework or expand it with additional dimensions and indicators, contingent on the contextually-embedded requirements of target firms or the nature of the investigation, to reflect specific goals and business strategies. The ultimate set of indicators in the model depends on the requirements of the target firms, the nature of the investigation, and the theoretical lens adopted in the study. For example, adopting the resource-based view (Barney, 1991) may necessitate adopting a performance measurement that includes indicators that are directly connected to specific resources of interest.

Third, this study draws on a rather small sample ($n = 78$), particularly with respect to the comparison between the outcomes of the IPEP and the simplified model. It is worth noting that

the sample size does not represent a limitation with respect to the IPEP model itself. In contrast to conventional statistical analysis, AHP does not require a large sample size in order to produce useful results (Cheng and Li, 2001; Sadeghi and Larimian, 2018), and previous AHP-based studies have used what would generally be viewed as very small sample sizes (e.g., $n < 10$); see Sipahi and Timor (2010) for a review. The sample of 78 New Zealand SMEs serves three purposes in this study. First, it demonstrates the application of the proposed models; for this purpose, a single firm would have sufficed. Second, we use the sample to understand whether variation exists in individual perceptions regarding export performance assessment; the sample clearly reflects such variation. Third, the sample allows us to undertake preliminary analysis to compare the results of the IPEP and the simplified approaches; while we find strong evidence that the two approaches provide broadly similar results, future work, involving more firms, will be necessary to provide stronger confidence in this preliminary, albeit promising, finding.

Fourth, there is evidence that industry-related factors such as competition and maturity, and firm-specific factors such as size, age, stage of internationalization, and earliness, affect managers' perceptions of opportunities and challenges in foreign markets (e.g., Aliasghar et al., 2019b; Gerschewski et al., 2020; Gerschewski et al., 2015). For example, Gerschewski and Xiao (2015) found evidence that, compared to other firms, INVs place more emphasis on financial performance. Since the versatile frameworks developed in this study seek to capture heterogeneities by explicitly accounting for different approaches, they can be used to capture export performance assessment in various types of SMEs. It also will be valuable to examine the role of industry- and firm-specific factors on SME managers' assessment of their firms' export performance. The developed measures can also be used to examine the relationship between export performance and other constructs of interest. Such studies should serve to

enhance our understanding of validity of the developed measures. These are important topics that go beyond the scope of this study, but represent useful directions for future research.

Fifth, the conceptualization and measurement of export performance in this study were based on the judgments and priorities of the key manager in each firm. In SMEs, the key manager tends to play a crucial role in the firm's decision making. However, in some firms, multiple managers may be involved with evaluating export performance. In such conditions, it would be advisable to account for the perspectives of multiple informants, potentially incorporating the opinions of a panel of managers (Dabić et al., 2019; Elbanna et al., 2020). Future studies could employ a combination of fuzzy AHP and the Delphi method to incorporate multiple decision makers' inputs and integrate them in a systematic manner to arrive at a single firm-level assessment that represents the group's aggregated view. For more information about the use of Delphi-AHP in supporting group decision making, see Lai et al. (2002) and Hsu et al. (2010).

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Figure 1 Proposed approach for measuring export performance

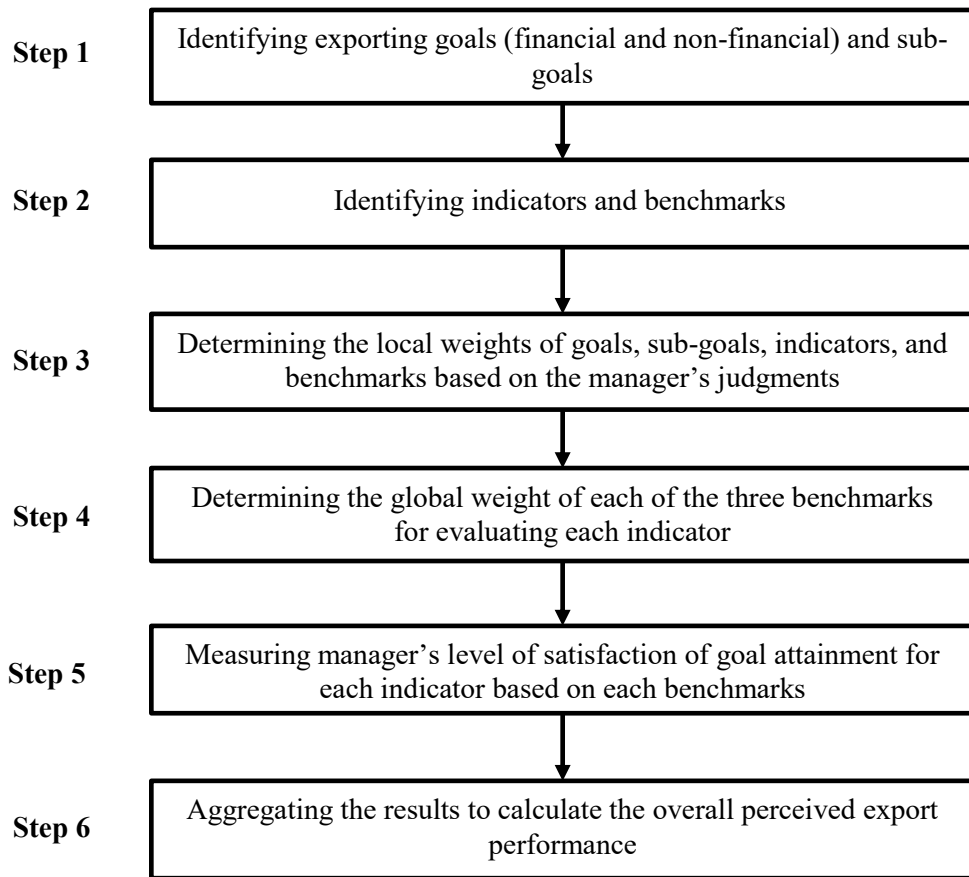


Figure 2 The IPEP framework

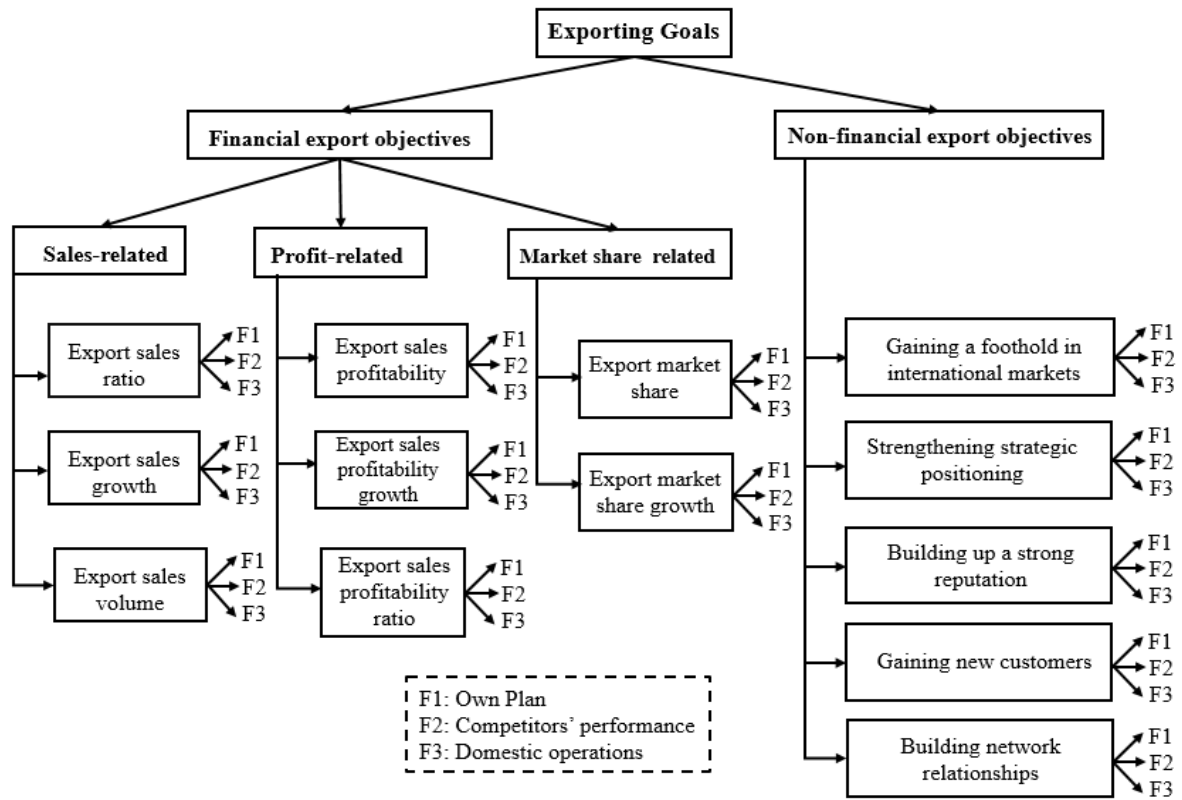


Figure 3 Variation in the relative importance of elements of IPEP framework in short-term perspective (n=78)

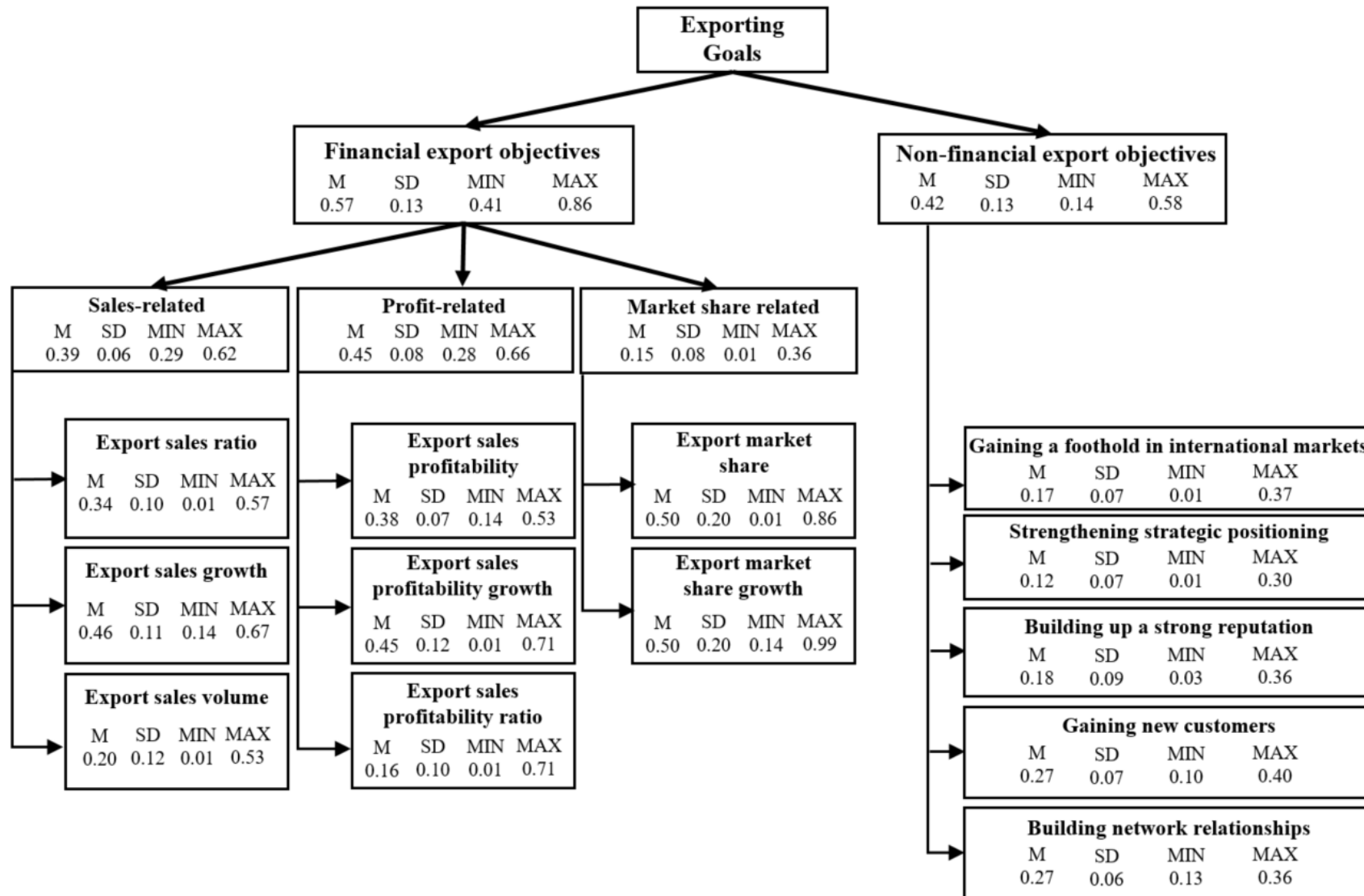


Figure 4 Variation in the relative importance of elements of IPEP framework in long-term perspective (n=78)

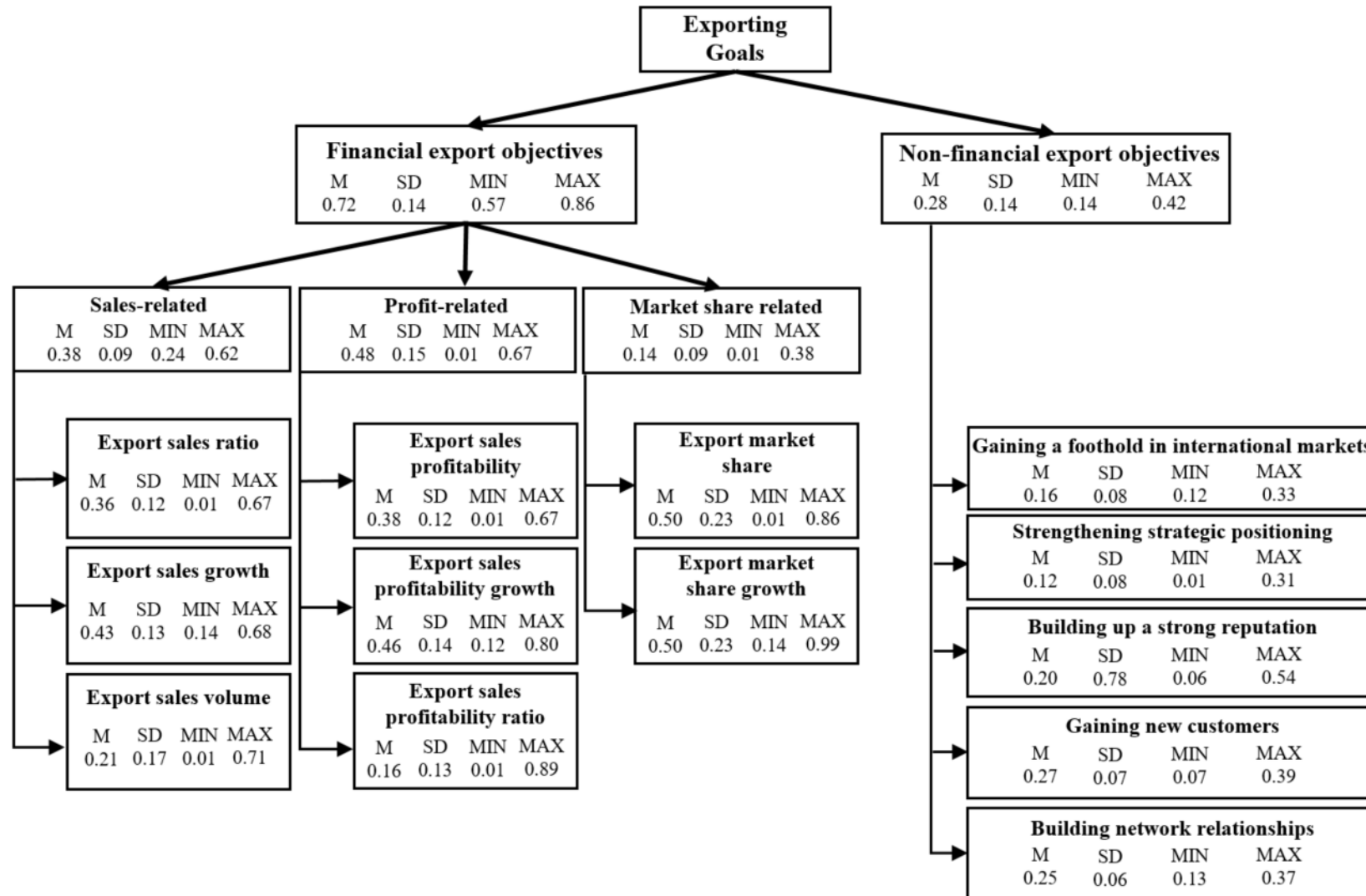
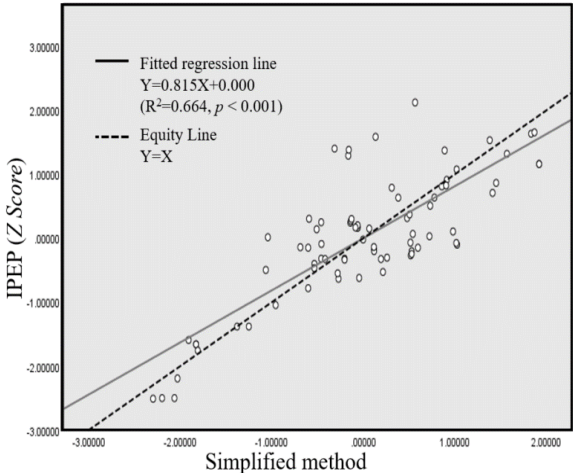
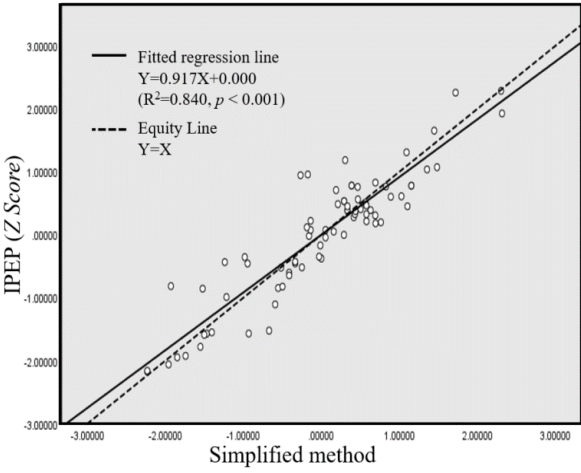


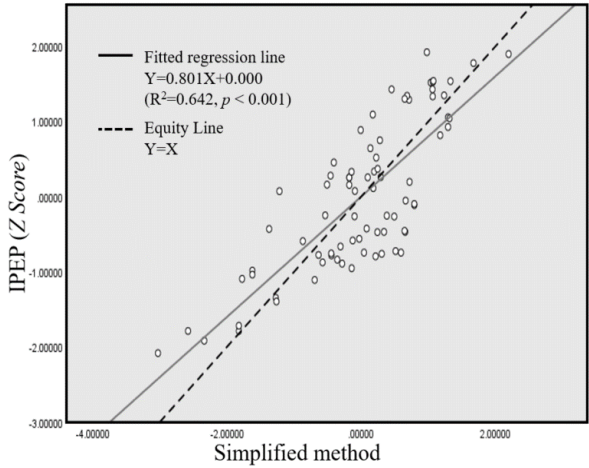
Figure 5 Graphical representation of the comparison of results obtained from the IPEP and the simplified methods



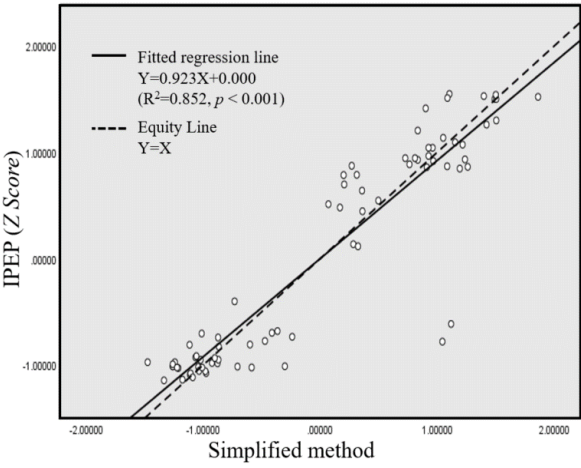
(a) Financial export performance, short-term



(a) Non-financial export performance, short-term



(a) Financial export performance, long-term



(a) Non-financial export performance, long-term

Table 1 Linguistic scales and their corresponding triangular fuzzy numbers (Chen et al., 2014)

Linguistic scale for level of importance	Triangular fuzzy scale
Equally important	$(2/5, 1, 5/2)$
Weakly more important	$(1/2, 2, 7/2)$
Fairly more important	$(3/2, 3, 9/2)$
Strongly more important	$(5/2, 4, 11/2)$
Absolutely more important	$(7/2, 5, 13/2)$

Table 2 Fuzzy AHP results for the sample firm

Goals	Sub-goals	Indicators	Local weight of indicator	Global weight of benchmarks for each indicator			Local satisfaction level (7-point scale)			Weighted satisfaction level		
				Own plan	Competition	Domes-tic	Own plan	Competition	Domes-tic	Own plan	Competition	Domes-tic
Financial (.580)	Sales-related (.339)	Export sales ratio	.184	.018	.011	.007	7	7	6	.124	.078	.044
		Export sales growth	.338	.033	.020	.013	7	6	5	.228	.122	.067
		Export sales volume	.478	.046	.029	.019	7	7	5	.323	.202	.095
	Profit-related (.478)	Export sales profitability	.529	.070	.050	.027	5	4	5	.350	.198	.135
		Growth in export sales profitability	.417	.055	.039	.021	5	4	4	.276	.156	.085
		Export sales profitability ratio	.055	.007	.005	.003	7	6	7	.051	.031	.020
	Market share-related (.183)	Export market share	.580	.028	.022	.012	4	4	3	.110	.090	.035
		Growth in export market share	.420	.020	.016	.008	4	5	5	.080	.081	.042
	Non-financial (.420)	Strategic factors (1.00)	Gaining a foothold in international markets	.042	.006	.008	.004	7	7	7	.043	.053
Strengthening the firm's strategic positioning			.181	.026	.033	.017	6	6	5	.156	.196	.087
Building up a strong reputation for the firm			.361	.052	.065	.035	5	5	4	.259	.325	.139
Gaining new customers			.278	.040	.050	.027	5	4	4	.200	.200	.107
Building network relationships			.138	.020	.025	.013	5	4	4	.099	.099	.053

Table 3 Aggregated weighted satisfaction score

	Own plan	Competition	Domestic	Final index
Financial	1.542	.959	.521	3.022
Non-financial	.757 ^a	.873	.416	2.045
Overall	2.299	1.832	.937	5.067

^aUsing values from the weighted satisfaction level column in Table 2, $.043 + .156 + .259 + .200 + .099 = .757$

Table 4 Comparing the IPEP framework and the simplified model

		IPEP framework	Simplified model
Dimensions of export performance assessment	Level of analysis	Firm-level	Firm-level
	Mode of assessment	Subjective	Subjective
	Type of performance	Financial and non-financial	Financial and non-financial
	Frame of reference	For each indicator, managers indicate the relative importance of three alternative benchmarks.	Managers indicate the single preferred benchmark that they often use in their assessments. This benchmark is used for assessing all the indicators.
	Time frame	Short- and long-term	Short- and long-term
	Criteria	8 financial indicators (categorized under 3 main financial criteria), and 5 non-financial indicators	3 financial, and 5 non-financial indicators
Method and survey	Method	Fuzzy analytic hierarchy process (AHP) for determining the relative weights of the criteria, indicators, and benchmarks	Exploratory factor analysis to create factors
	Type of survey questions	Pairwise comparison and Likert-scale questions	Likert-scale questions
	Length of questionnaire and estimated completion time	More than 70 questions for each time frame (excluding demographic and general questions) Completion time: 30 minutes	16 questions for each time frame (excluding demographic and general questions) Completion time: 5 minutes
Advantages	<ul style="list-style-type: none"> • Providing a detailed and comprehensive measurement • Accounting for the relative weight of goals, criteria, indicators, and benchmarks • Accounting for the uncertainties in the manager's judgments by employing linguistic variables for data collection, and fuzzy logic for data analysis 	<ul style="list-style-type: none"> • Short questionnaire • Easy to implement • Easy analytical procedure • Likert scale is easy to comprehend 	
Disadvantages	<ul style="list-style-type: none"> • Long questionnaire • Complex and time-consuming analytical procedure • Participants may not be familiar with pairwise comparison scale 	<ul style="list-style-type: none"> • Less detailed measurement • Discrete numerical values in the Likert scale may not fully reflect the imprecision associated with human judgments • Does not account for the potential variation in the importance of benchmarks 	
Application	<ul style="list-style-type: none"> • Decision support tool for practical purposes • Deep exploration of export performance 	<ul style="list-style-type: none"> • Measuring export performance in empirical studies 	

Table 5 ANOVA results for level of importance of benchmarks in assessment of different export performance indicators

Time frame	Benchmarks Criteria	Own Plans (O)				Competitor's performance (C)				Domestic performance (D)				Sig.	Conclusion based on confidence intervals for the mean
		Mean	SD	MIN	MAX	Mean	SD	MIN	MAX	Mean	SD	MIN	MAX		
Short-term	Sales-related	.46	.06	.30	.66	.34	.69	.01	.50	.20	.08	.01	.39	***	O > C > D
	Profit-related	.50	.10	.28	.89	.32	.07	.01	.68	.18	.08	.01	.38	***	O > C > D
	Market share-related	.51	.11	.31	.10	.34	.09	.01	.62	.15	.11	.01	.38	***	O > C > D
	Strategic	.59	.17	.31	.71	.33	.08	.01	.62	.15	.10	.01	.38	***	O > C > D
Long-term	Sales-related	.48	.08	.30	.66	.33	.09	.01	.44	.19	.09	.01	.38	***	O > C > D
	Profit-related	.52	.11	.31	.89	.29	.08	.01	.52	.18	.09	.01	.42	***	O > C > D
	Market share-related	.54	.12	.29	.89	.33	.08	.01	.57	.13	.10	.01	.33	***	O > C > D
	Strategic	.58	.15	.30	.89	.30	.09	.07	.49	.12	.10	.01	.34	***	O > C > D

*** p < .001

Table 6 Factor analysis results

Factors and Items	EFA loadings			
	Short-term		Long-term	
	Fin	Non-Fin	Fin	Non-Fin
1. Financial export performance				
(a) Export sales ratio	.811	.047	.815	-.172
(b) Export sales profitability	.756	-.173	.817	.078
(c) Export sales market share	.625	-.150	.621	-.334
2. Non-financial export performance				
(a) Gaining a foothold in international markets	-.111	.758	-.118	.835
(b) Strengthening strategic positioning	.035	.842	-.245	.866
(c) Building a strong reputation for the company	.017	.826	-.170	.867
(d) Gaining new customers	-.292	.705	-.182	.812
(e) Building network relationships	-.374	.746	.044	.790
% variance explained	23.226	38.421	23.201	45.381
Cronbach's alpha	.615	.848	.642	.901

Note: Extraction is principal component and rotation is varimax. Figures in bold are the higher factor loadings. Total variance explained values are 61.65% for short-term and 68.58% for long-term.

Appendix A: Pairwise comparison questionnaire

Instructions:

For each the following questions, please assess the relative importance of each pair of items, with respect to how your firm assesses export performance. If the attribute on the left is more important than the one on the right, put your tick mark to the left of centre, under the most appropriate importance level. If the attribute on the right is more important than the one on the left, put your tick mark to the right of centre, under the most appropriate importance level.

The descriptions of relative importance are as follows:

- **Equally** – Equally important
- **Slightly** – Slightly more important
- **Fairly** – Fairly more important
- **Strongly** – Strongly more important
- **Extremely** – Extremely more important

For example, a typical question may appear as follows.

With respect to ‘financial export objectives’:

How important are ‘Sales-related criteria’, compared with ‘Profit-related criteria’?

Sales-related criteria	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Profit-related criteria

If *Sales-related criteria* are strongly more important than *Profit-related criteria* for your firm, you might respond as shown below:

Sales-related criteria	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Profit-related criteria

Alternatively, if *Profit-related criteria* are slightly more important than *Sales-related criteria* for your firm, you might respond as shown below:

Sales-related criteria	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Profit-related criteria

Sample questions in the questionnaire:

1. In evaluating financial export objectives, please indicate the relative importance of sales, profit, and market share, marking one circle for each comparison (three comparisons for each time period).

With respect to: Financial export objectives

Over the most recent financial year										Over the past 5 financial years									
	Extremely	Strongly	Fairly	Slightly	Equally	Slightly	Fairly	Strongly	Extremely		Extremely	Strongly	Fairly	Slightly	Equally	Slightly	Fairly	Strongly	Extremely
Sales	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Profit	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sales	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Market Share	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Profit	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Market Share	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2. In assessing your firm's financial objectives (sales, profit, and market share) in export markets, please indicate the relative importance of each of the pairs of indicators. (For example, in evaluating sales-related criteria, please indicate the relative importance of sales ratio, sales growth, and sales volume for each time period.)

With respect to: Sales-related criteria

Over the most recent financial year										Over the past 5 financial years									
	Extremely	Strongly	Fairly	Slightly	Equally	Slightly	Fairly	Strongly	Extremely		Extremely	Strongly	Fairly	Slightly	Equally	Slightly	Fairly	Strongly	Extremely
Sales ratio	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sales growth	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sales ratio	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sales volume	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sales volume	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Sales growth	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. In assessing your firm's non-financial objectives in exporting, please indicate the relative importance of each of the pairs of indicators, marking one circle for each comparison.

With respect to: Non-financial export objectives

	Over the most recent financial year										Over the past 5 financial years										
	Extremely	Strongly	Fairly	Slightly	Equally	Slightly	Fairly	Strongly	Extremely		Extremely	Strongly	Fairly	Slightly	Equally	Slightly	Fairly	Strongly	Extremely		
Gaining a foothold in international markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Strengthening strategic positioning	Gaining a foothold in international markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Strengthening strategic positioning
Gaining a foothold in international markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building up a strong reputation	Gaining a foothold in international markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building up a strong reputation
Gaining a foothold in international markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gaining new customers	Gaining a foothold in international markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gaining new customers
Gaining a foothold in international markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building network relationships	Gaining a foothold in international markets	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building network relationships
Strengthening strategic positioning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building up a strong reputation	Strengthening strategic positioning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building up a strong reputation
Strengthening strategic positioning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gaining new customers	Strengthening strategic positioning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gaining new customers
Strengthening strategic positioning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building network relationships	Strengthening strategic positioning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building network relationships
Building up a strong reputation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gaining new customers	Building up a strong reputation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Gaining new customers
Building up a strong reputation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building network relationships	Building up a strong reputation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building network relationships
Gaining new customers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building network relationships	Gaining new customers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Building network relationships

Online Appendix

Fuzzy sets and fuzzy numbers

Decision making in real-world problems is characterized by uncertainty and imprecision, and in many situations, the judgments of decision makers cannot be truly reflected by crisp values. Zadeh (1965) introduced the fuzzy sets theory as an effective method for mathematical representation of such uncertainties and imprecisions associated with human cognitive process. Fuzzy numbers are used when decision makers cannot express their judgment in the form of crisp numeric values, but can provide an interval judgment (Dağdeviren and Yüksel, 2008). In contrast to the regular, real numbers, the value of a fuzzy number is imprecise. In other words, rather than referring to a single value, a fuzzy number is defined by a set of possible values (regarded to as degree of membership). Each fuzzy number is defined by a membership function which can be depicted on a two-axis diagram. The x-axis pertains to the domain of the fuzzy number and the y-axis indicates the degree of membership that ranges between zero and one. A fuzzy number can be represented by various shapes, but triangular fuzzy numbers (TFNs) are the most widely-used one (Kahraman et al., 2015) and has been used in this study. A graphical representation of a TFN, \tilde{M} is shown in **Figure 1**. A TFN is defined by three real numbers expressed as (l, m, u) , where l and u are minimum and maximum possible values and m represents the most likely value that describe a fuzzy event (Zadeh, 1965). The membership function of a TFN can be defined as Eq. (1). The algebraic operations on triangular fuzzy numbers can be found in Zimmermann (2011) and Kahraman et al. (2003).

$$\begin{cases} (x - l)/(m - l) & \text{if } l \leq x \leq m, \\ (u - x)/(u - m) & \text{if } m \leq x \leq u, \\ 0 & \text{otherwise.} \end{cases} \quad (1)$$

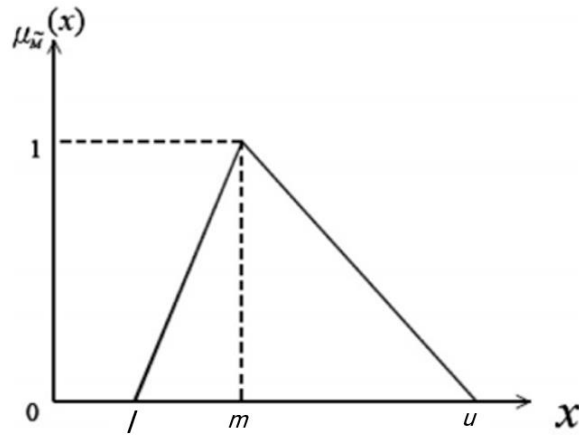


Figure 1 Membership function of a triangular fuzzy number $\tilde{M} = (l, m, u)$

Introducing fuzzy logic in AHP allows us to better deal with uncertainty and imprecision in subjective managerial judgments by taking into account the optimism/pessimism rating attitude of evaluators. For example, a linguistic term such as “significantly more important” can be associated with a TFN defined as (l, m, u) , which implies that its domain ranges from l to u , with m being the most probable value. By incorporating such linguistic variables in the pairwise comparisons, two individuals may use the same term to express their judgment, although their understanding from that term may be slightly different.

The steps of Chang’s extent analysis method

Let $X = \{x_1, x_2, \dots, x_n\}$ be an object set, and $U = \{u_1, u_2, \dots, u_m\}$ be a goal set. According to the method of Chang extent analysis (Chang, 1992), each object is taken and extent analysis for each goal, g_i , is performed, respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{g_i}^1, M_{g_i}^2, \dots, M_{g_i}^m \quad i = 1, 2, \dots, n \quad (1)$$

Where all the $M_{g_i}^j$ ($j = 1, 2, \dots, m$) are triangular fuzzy numbers. The steps of Chang’s extent analysis can be given as in the following:

Step 1. The value of fuzzy synthetic extent with respect to i -th object is defined as Eq. (2)

$$S_i = \sum_{j=1}^m M_{gi}^j \otimes \left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} \quad (2)$$

To obtain $\sum_{j=1}^m M_{gi}^j$ perform the fuzzy addition operation with m values of the extent analysis values for

a particular matrix such that:

$$\sum_{j=1}^m M_{gi}^j = \left(\sum_{j=1}^m l_i, \sum_{j=1}^m m_i, \sum_{j=1}^m u_i \right) \quad (3)$$

And to obtain $\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1}$, perform the fuzzy addition operation of M_{gi}^j ($j = 1, 2, \dots, m$) values

such that:

$$\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j = \left(\sum_{i=1}^n l_i, \sum_{i=1}^n m_i, \sum_{i=1}^n u_i \right) \quad (4)$$

and then compute the inverse of the vector in Eq. (4) such that

$$\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^n u_i}, \frac{1}{\sum_{i=1}^n m_i}, \frac{1}{\sum_{i=1}^n l_i} \right) \quad (5)$$

Step 2. The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as:

$$V(M_2 \geq M_1) = \sup[\min(\mu_{M_1}(x), \mu_{M_2}(y))] \quad (6)$$

And can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = \text{hgt}(M_1 \cap M_2) = \mu_{M_2}(d)$$

$$= \begin{cases} 1, & \text{if } m_2 \geq m_1 \\ 0, & \text{if } l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise} \end{cases} \quad (7)$$

Figure 2 illustrates Eq. 7 Where d is the ordinate of highest intersection point D between μ_{M_1} and

μ_{M_2} .

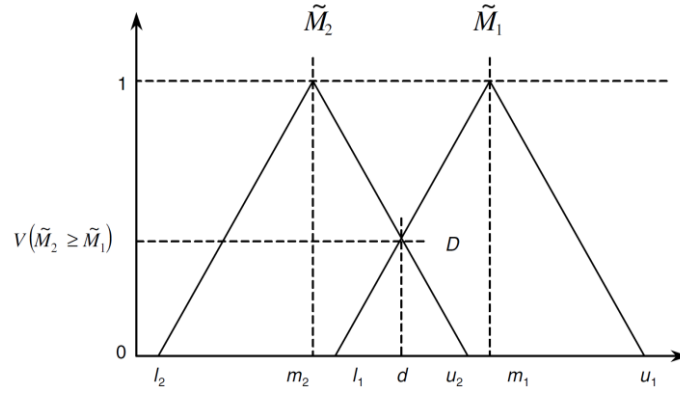


Figure 2 The degree of possibility of $\tilde{M}_2 \geq \tilde{M}_1$

To compare M_1 and M_2 , we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

Step 3. The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i ($i = 1, 2, \dots, k$) can be defined by

$$V(M \geq M_1, M_2, \dots, M_k) =$$

$$V(M \geq M_1) \text{ and } V(M \geq M_2) \text{ and } \dots \text{ and } V(M \geq M_k)$$

$$= \min V(M \geq M_i), i = 1, 2, \dots, k \quad (8)$$

Let us assume that Eq. (9) is true:

$$d'(A_i) = \min V(S_i \geq S_k) \quad (9)$$

For $k = 1, 2, \dots, n; k \neq i$. Then the weight vector is given by

$$W' = (d'(A_1), d'(A_2), \dots, d'(A_n))^T \quad (10)$$

Where A_i ($i = 1, 2, \dots, n$) are n elements.

Step 4. Through normalization, the weight vectors are reduced to Eq. (11):

$$W = (d(A_1), d(A_2), \dots, d(A_n))^T \quad (11)$$

Where W is a non-fuzzy number.

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