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METHODOLOGY IN RESEARCH: HOW TO ASSURE RELIABILITY AND VALIDITY OF CONSTRUCTS IN LOGISTICS RESEARCH

Summary. The purpose of this article is to present the research methods in developing measurement scales for the constructs in logistics research. The objective is to determine the most appropriate method for a specific research framework and to add to the understanding of logistics research rigor through the concept of validity and reliability as it concerns logistics research. Although validity means many things in common speech, validity in research means procedures have been used to ensure that the conclusion from a research study is valid and the research results can be stated with some confidence.

Briefly, we show the procedure of developing measurement scale for construct *innovation* in logistics outsourcing performance research. In order to assure the reliable measurement instrument the development of a multi-item scale for the construct must show strong evidence of reliability as well as convergent validity in a research sample.

We test our conceptualization using data from a survey, conducted in the Slovenian market among the two largest Slovenian logistics service providers (LSPs) and their main customers. We present the scale development and refinement process in which we measure for validity and reliability with multivariate statistical methods (Explanatory Factor Analysis, Confirmatory Factor Analysis, and Structural Equation Modeling using Partial Least Squares). Finally, we discuss measurement assessments for validity and reliability.

METODOLOGIA W BADANIU: JAK ZAPEWNIĆ RZETELNOŚĆ I WAŻNOŚĆ KONCEPCJI W BADANIACH LOGISTYCZNYCH

Streszczenie. Celem niniejszego artykułu jest prezentacja metod badawczych, służących tworzeniu skali pomiarowej dla koncepcji w badaniach logistycznych. Główne cele to ustalenie najwłaściwszej metody dla danej struktury badań oraz lepsze zrozumienie rygoru badań logistycznych w aspekcie ich ważności i rzetelności w zakresie badań logistycznych. Pomimo że *ważność* może oznaczać wiele rzeczy w mowie potocznej, *ważność badań* oznacza procedury użyte w celu zapewnienia takich wniosków z procesu badawczego, które są ważne, i takich rezultatów badań, które mogą być określone z dużą pewnością.

Mówiąc w skrócie, w niniejszym artykule ukazana jest procedura wypracowywania skali pomiarowej do stworzenia innowacji w wyniku badań *outsourcingu* w logistyce. W celu zapewnienia rzetelnego instrumentu pomiarowego rozwój wieloczęściowej skali koncepcji musi dowodzić rzetelności oraz zbieżnej ważności w próbce badawczej. Badamy konceptualizację, używając danych z ankiety przeprowadzonej na słoweńskim

rynku wśród dwóch największych słoweńskich dostawców usług logistycznych (LSPs) oraz ich głównych klientów. Prezentujemy rozwój skali oraz proces udoskonalania, w którym mierzymy ważność i rzetelność z użyciem wielozmiennych metod statystycznych (Explanatory Factor Analysis, Confirmatory Factor Analysis oraz Structural Equation Modeling using Partial Least Squares). W części końcowej omawiamy ocenę pomiarów pod względem ważności i rzetelności.

1. INTRODUCTION

When speaking of methodology in logistics research, there is often a question among researchers as to which methodology to employ. Many logisticians would say that their research tends to be more positivistic in nature thus more quantitative approaches for research method are appropriate, others tend to be more interpretative in nature, so more qualitative approaches are utilized. The truth is that all forms of research are needed to solve problems. Researchers suggest that as the discipline matures, rigorous research methods and techniques should become the standard for developing and testing logistics theory [23].

A research design defines the study's purpose. Logisticians, like other social science researchers, must give clear definition, operationalization, and testing of relationships among important constructs. They must also consider the acceptable sample size and corresponding response rate, individual or organizational behaviors and the choices of methodology and methods. The choice of research methodology must be appropriate for the research problems and objectives.

As Mentzer and Flint [23] stated »The better the research design and theory test, the greater the strength of support for the theory in question«.

Research methodologies range from objective, scientific (quantitative) research styles to the subjective, interpretive, more constructive (qualitative) styles. Qualitative research methodologies were developed in social sciences and are often criticized for being unscientific, sometimes too personal and full of bias. Quantitative research methodologies usually incorporate statistical elements, designed to quantify the extent to which a target group is aware of, thinks, or believes. Studies tend to emphasize the measurement and the analysis of causal relationships between variables.

Research methods are the data collection techniques which refers to specific procedures. The research question derived from theory observation and literature review leads to specific hypotheses and construct where appropriate methodology and methods are employed. Research methods are generally described as qualitative or quantitative in practice, the methods tend to be both. First, qualitative methods create meanings and explanations to research phenomena. Data collection methods include observation, interviews and questionnaires, case studies and research impressions, and reactions. The procedure to collect specific data is often time-consuming work, and the testing of validity is crucial.

Quantitative research methods, on the contrary, can provide wide coverage of a range of situations, are faster, and can be economical (i.e. when statistics are aggregated from large samples). Many researchers use both, qualitative and quantitative methods, and give examples of how they have been able to combine these different forms of data with good results in logistics science research. In research, regardless of the particular methodology selected, much of the achievement of rigor is in the concepts of validity.

As the purpose of this article is to present the research methods in developing measurement scales for the constructs in logistics research, the objective is to determine the most appropriate method for a specific research framework. We show the procedure of developing measurement scale for construct *innovation* in logistics outsourcing performance research. In order to assure the reliable measurement instrument the development of a multi-item scale for the construct must show strong evidence of reliability as well as convergent validity in a research sample.

We test our conceptualization using data from a survey, conducted in the Slovenian market among the two largest Slovenian logistics service providers (LSPs) and their main customers. We present the scale development and refinement process in which we measure for validity and reliability with

multivariate statistical methods (Explanatory Factor Analysis, Confirmatory Factor Analysis, and Structural Equation Modeling using Partial Least Squares). Finally, we discuss measurement assessments for validity and reliability.

2. LITERATURE REVIEW

The strategic edge of LSPs in markets is influenced by the manner of how they develop and manage their customer relationships [15]. Logistics outsourcing arrangements have strategic implications for customers since they directly affect the boundaries of the firm and influence their core competencies and resources [11]. The complexity of logistics outsourcing, and its impact on different business processes of the customer, point out the need of inter-organizational collaboration between LSP's and their customers. Slovenia, a rather small economy, was chosen since logistics outsourcing is increasing in importance as logistics organizations widen their efforts towards new markets in the south-eastern region of Europe. The analysis of the Slovenian market in the field of logistics outsourcing shows that the level of the logistics outsourcing relationships is still lower than that in more developed economies [21].

To drive change and improvement in the overall business relationship, LSPs and customers must work towards a common set of goals and objectives, and establish a meaningful exchange of knowledge relating to planning, management, and performance measurement. In an environment of increasing logistics costs, managing logistics activities will remain a daunting task, but managers believe that collaboration is now the key to improving efficiency. Working together is preferable, not only for the LSPs and their customers, but also other key stakeholders. Due to financial restrictions in the region and lack of investment in logistics technology, organizational innovation could be the key to improved efficiency in logistics activities.

2.1. Innovation

The global marketplace has driven businesses to look for new ways to innovate [12]. However, when considering innovation, people focus on technological as opposed to service innovation. In order to purposely manage the innovation in logistics, it is crucial to have an understanding of how innovation occurs. In the Flint et al. [12] study, there is strong evidence that customers expect service providers to continuously drive towards innovation for increasing their value to customers, and for their own sustained competitive position. Customers have expressed a growing demand for more effective logistics solutions. From the individual point of view, the innovativeness is conceived as the degree to which an individual, compared to others in the social system, is relatively early in adopting something new [19]. Firm innovativeness, as defined by Hurley and Hult [18], means openness to new ideas as an aspect of a firm's culture. Innovation implies the generation, acceptance, and implementation of new ideas, processes, products, or services [6, p.517]. This definition is close to Rogers [28] as "an idea, practice or object that is perceived as new by an individual or other unit of adoption". The knowledge sharing, which we mentioned above, is closely related to organizational innovation. Many scholars stress the importance of such an orientation to enhancing innovation capability [e.g. 9; 29; 5].

Some researchers define the logistics service providers' orientation towards innovation as proactive improvement [10; 11]. Except for studies by Engelbrecht [11], Flint et al. [12] and Deepen [10] innovation has received very little attention in current logistics outsourcing research. Their conclusions are that logistics innovation still requires substantial further research, since it is a major driver of logistics outsourcing performance, as shown in the empirically tested findings.

3. RESEARCH DESIGN

3.1. Operationalization of the variables

In order to assure relevant indicators for the constructs, in-depth interviews were conducted in March–April 2008. Fifteen managers of two companies from the list of the largest Slovenian LSPs and their main customers participated. The participants represented two different levels of managers (operational and top management) and have several years of experience with logistics outsourcing relationships. Each individual was questioned about the relationship variables with their partner (provider or customer) in logistics outsourcing. The interviews were audio taped and then transcribed.

As stated before, innovation is increasing the value creation for the customers and for the LSPs own sustained competitive position. The hypothesis of the positive effect of innovation on logistics outsourcing performance is supported by transaction cost theory. The optimization process performed by the LSP results the lower costs for customers. In accordance with social exchange theory, the LSP can expect to be rewarded for the improve services and will strive for higher goal achievement. Some measurable effects can be obtained if the LSPs are constantly improving their efforts, supported by innovation.

Innovation is included in the logistics outsourcing research of Engelbrecht [11], Flint et al. [12] and Deepen [10]. They call the construct "proactive improvement," with a very similar definition as other researchers [e.g. 12] use for innovation orientation. For the operationalization of the construct, the scale developed by Engelbrecht [11] and adopted by Deepen [10] was selected with slight modifications, as suggested by logistics experts in Slovenian companies, as table 1 shows.

Table 1

Indicators for the measurement of the construct of innovation

	Please indicate the level of agreement with the following statements on the innovation.
INN 1	The LSP continuously makes suggestions for improvements of activities, even those outside its direct contract responsibility.
INN 2	In changing business situations the LSP by itself modifies logistics processes, if this is necessary and beneficial for us.
INN 3	The LSP continuously makes suggestions for improvements in logistics performance.
INN 4	The LSP services follow the improvement and progress in logistics.
INN 5	The LSP shows a high level of innovation.

3.2. Questionnaire Design and Pretest

The development of the questionnaire was based on the conceptualization of the variable theorized to affect the outsourcing relationship and performance. To measure the construct, the seven point Likert-type scale was utilized, which was anchored with responses to the statements ranging from 1 = strongly disagree to 7 = strongly agree. Since the multi-item Likert scales are a common and recommended means of collecting data on latent constructs [25] and because some disagreement exists on the question of how many points the scale should have, we chose the wider scale in order to better differentiate between answers. Additionally, structural equation modeling will be utilized requiring that the scale of the observed variables must be continuous [4]. We chose to use the seven-category Likert scale because it is assumed to be suitable to fulfill the requirement of continuously scaled data [3].

In the second part of the questionnaire, participants were invited to respond to a set of questions describing themselves, their company, and the activities that are outsourced to LSPs. Because the empirical study relied completely on the perceptions of key informants, it was important that respondents were competent. Hence, the questionnaire contained the final set of questions that refers to the respondent's position and tenure with the company.

The questionnaire and the cover letter for this study were first (as pretest) sent out by e-mail to the sample respondents consisting of 18 marketing relationship experts and logistics managers. Both documents were discussed in-depth with the respondents. Their comments and suggestions for improvements were used to revise the questionnaire. The results from the pretest indicated that respondents had no difficulty in comprehending the directions or questionnaire items. This procedure has been recommended as a means to avoid logical errors, misunderstandings and misinterpretations [8, 22].

3.3. Data Collection

The unit of analysis for the present research was the specific logistics service provider–customer relationship. Empirical data were gathered in the survey among logistics managers of manufacturing and retail companies who built long term relationships in logistics outsourcing with two of the largest LSPs in Slovenia. The study was conducted in cooperation with the chosen LSPs. Based on the LSPs' customer lists, a total of 67 questionnaires were sent resulting in 58 useable responses after the two follow-ups, representing a response rate of 86.5%.

3.4. Measurement Assessment

The explanatory value of any empirical analysis depends on the quality of the underlying measurement. Besides measuring objectively, the reliability and validity of the measurement instrument are important. Several steps were taken to assess the reliability and validity of the *innovation* scale. As Anderson and Gerbing [2] suggested, a two-step approach became the widely accepted standard and it was used in our research as well.

For the measurement of a construct, empirically observable indicators are utilized that reflects the characteristics of the latent variable. Constructs can generally be conceptualized as one-factor, or as multi-factor constructs, as Homburg and Giering [16] argue. In the one-factor case, the construct is represented by only one factor on which all measured indicators directly load. The measurement of one-factor constructs can be performed through a single indicator or through several indicators. For more complex constructs, multiple indicators are employed [20; 24]. Formative or reflective indicators can be used [16]. The construct *innovation* is represented by reflective indicators, since they better capture the variable. It should be noted that the methods used to evaluate validity and reliability of formative indicators are still very new and scarcely tested.

For the assessment of reliability and validity, exploratory factor analysis and the Cronbach alpha coefficient are used in this study. Due to the relatively small sample size, the threshold values for factor loadings and communalities were increased. Small sample size is the reason that Partial Least Squares regression (PLS) has been employed to assess the measurement model. PLS was developed [30] as a general method for the estimation of path models involving latent constructs indirectly measured by multiple indicators. It was designed to deal with multiple regressions when the data sample is small, where there are missing values, or in cases of multicollinearity [26]. PLS models are defined by two sets of linear equations: the inner model, which specifies the relationships between unobserved or latent variables, and the outer model that specifies the relationships between latent variables and their associated observed or manifest variables. The approach is well suited and widely used because of the reliability and ease of use of its analysis procedures, and its modeling flexibility.

4. ANALYSIS AND RESULTS

To present the results of customer statements of variable innovation, univariate statistical analyses of variables (the calculation of arithmetic means and standard deviations) were performed. Data was analyzed using the SPSS 15.0 statistical package.

The respondents on average expressed the lowest level of agreement with the statement: The LSP continuously makes suggestions for improvements of activities, even those outside its direct contract

responsibility (mean: 3.88, standard deviation 1.50). The statement shows that the provider cares about the costs of logistics activities since being innovative usually means operating with higher costs on short basis. For all others measured variables of *innovation* the mean scores are 4 or above 4. This indicates that the respondents have on average more than a neutral attitude to the statements. Customers expressed the greatest agreement with the statement: In changing business situations the LSP by itself modifies logistics processes, if this is necessary and beneficial for us (mean: 4.52, standard deviation 1.30). The results shows that LSPs should be more innovative.

There were no statistically significant differences between the customers of either LSP, so further assessment was made for the sample as a whole.

4.1. Check for Unidimensionality

The set of indicators for the construct was initially examined using exploratory factor analysis (PCA – Principal Components Analysis*)* to identify items not belonging to the specified domain. Only in cases where a single factor is extracted can convergent validity be assumed, and that factor must explain at least 50% of the variance of its indicators. Hair *et al.* [14] suggest minimum factor loading of 0.70 for small samples such as 60 units. Our sample has 58 units, so items with a loading of less than 0.75 and communality less than 0.40 were discarded. To examine the appropriateness of factor analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was employed. Values between 0.5 and 1.0 indicate that factor analysis is appropriate [1; 22].

To assess internal consistency reliability Cronbach's Alpha coefficient was calculated. A value of 0.6 or less generally indicates unsatisfactory internal consistency reliability. Its value tends to increase when the number of scale items rises [22]. For PLS the threshold value is 0.70. Cronbach's Alpha for latent variable of *innovation* is 0.936.

Following basic descriptive analysis (examination of coding errors, means and standard deviations) and EFA, the data were subjected to CFA by means of PLS. The analysis was carried out using the SmartPLS 2.0 statistical package [27].

4.2. Convergent validity and reliability measures

The reliable and valid measurement of a construct is the main goal of measurement model development. We assessed the adequacy of the measurement model through examination of individual item reliabilities, and convergent validity.

Composite reliability that measures internal coherency of all indicators related to the construct is also called construct reliability. Threshold value should be greater than 0.6. Composite reliability for involvement and knowledge sharing is 0.886, so the construct is reliable.

Convergent validity is the extent to which the scale correlates positively with other measures in the same construct. T-tests for path coefficients have been calculated after computing a bootstrap method in order to validate all the model's items for convergent validity [7; 2]. T-values greater than $|1.96|$ determine a significant path at $p \leq 0.05$. A single indicator was strongly correlated with the latent variable.

The convergent validity measure represents the common variance between the indicators and their construct. It is measured by the Average Variance Extracted (AVE) and the acceptable threshold should be superior to 50% [13]. An AVE of 0.721 complies with this pre-requisite.

The communality index measures the quality of the measurement model for each block of indicators. The cross-validated communality index measures the quality of the measurement model for each block. It is calculated by a blindfolding procedure available in SmartPLS. Table 2 represents results for convergent validity and reliability for latent variable *innovation.*

Table 2

Convergent Validity and Reliability Measures

Latent variable	*Cronbach Alpha*	*Composite reliability*	*AVE*	*Communality*	*Cross-validated communality (H^2)*
INN	0.936	0.951	0.796	0.796	0.674

5. CONCLUSIONS

The current study set out to generate a measurement tool for investigating indicators of *innovation* in logistics outsourcing relationships. The authors completed the instrument through literature review and conducted in-depth interviews with experts in logistics. The sample was restricted to LSPs in Slovenia and their customers, and the analysis was undertaken with data collected from the customer side. Empirical data in the survey was gathered from logistics managers of manufacturing and retail companies who had established long term relationships in logistics outsourcing. A total of 67 questionnaires were sent, resulting in 58 useable responses after the two follow-ups, representing a response rate of 86.5%.

Several steps were taken to assess the reliability and validity of the *innovation* scale. The indicators were evaluated in pre-tests for their relevance and suitability, and they were slightly modified. Following basic descriptive analysis (examination of coding errors, means and standard deviations), the data was subjected to exploratory factor analysis (EFA - PCA). To ensure that this method of factor analysis was appropriate, the KMO test was performed. All five indicators remained and they created the measurement model. To assess the internal consistency reliability, Cronbach's Alpha was used and its value of 0.936 indicates good internal consistency reliability. The measurement model is then tested for validity and reliability with CFA in order to become a part of the structural model. Partial least squares regression was used as a method of SEM. We assessed the adequacy of the measurement model through examination of individual item reliabilities, and convergent validity.
The composite reliability for *innovation is* 0.951, so the construct is reliable. A single indicator was strongly correlated with the latent variable. An AVE of 0.796 complies with an acceptable threshold, being over 50%. The development of a multi-item scale for *innovation* in logistics outsourcing relationships presents strong evidence of reliability as well as convergent validity.

The results of this study must be interpreted in view of certain limitations. The sample was restricted to LSPs in Slovenia and their customers, and the analysis was undertaken with data collected from the customer side. Therefore, in future this scale could be tested in other cultural contexts to further establish its validity.

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