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Validation of supply chain integration scales and the effect that size, level of vertical integration, industry and country have on their value

Juan A. Marin-Garcia[1], Rafaela Alfalla-Luque[2], Carmen Medina-López[2]

Abstract (English) Academic literature would appear to indicate that supply chain integration is a major factor in explaining the performance of companies. The results are nevertheless inconclusive. Certain authors put forward the idea that the vast range of results obtained are due, amongst other things, to the fact that there is no exactness to the group of scales used, no-one has yet published an analysis of the measurement models nor clear benchmarks. In this paper, we present the theoretical definition of four supply chain integration scales (clients, suppliers, external and internal) and the convergent and discriminant validity of a measurement instrument based on a list of items taken from earlier papers. We also propose a benchmark to interpret the scales by percentiles, using a diverse international sampling broken down into sub-samples based on sector, type of company, size of company and degree of vertical integration.

Keywords: Supply Chain Integration, Scale Validation, Performance

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[1] Juan A. Marin-Garcia (✉) ROGLE- Departamento de Organización de Empresas (DOE)Universidad Politécnica de Valencia. Camino de Vera s/n. Valencia. SPAIN Email: jamarin@omp.upv.es

[2] Dpto. Economía Financiera y Dirección de Operaciones. F.CC. Económicas y Empresariales de Sevilla. Universidad de Sevilla. Ramón y Cajal, 1. 41018 Sevilla. alfalla@us.es; cmedina@us.es

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Introduction

The concept of supply chain integration is of great interest for academics working in operational management (Flynn et al., 2010a). One of the main reasons is that it greatly influences the competitive advantage of companies (Flynn et al., 2010a). But it is also a concept whose definition and whose operationalization are still up for debate. There is no consensus as to which components to include, nor how to measure them (Flynn et al., 2010a; Roth et al., 2008; Zhu et al., 2008). In fact, in research carried out so far, it is common to be confronted with a variety of proposals and this means that demonstrating the effects of supply chain integration on the performance of companies is inconclusive giving contradictory results (Flynn et al., 2010a).

According to recent research, supply chain integration is comprised of two primary dimensions: internal integration and external integration. External integration can then be further subdivided: integration with clients and integration with suppliers (Alfalla-Luque y Medina-López, 2009; Chang et al., 2007; Flynn et al., 2010a; Flynn et al., 2010b). Nevertheless, there is a slight bias in research, both empirical and conceptual, that has leant towards external rather than internal integration (Zhao et al., 2011). This is why there have been calls so that any future research takes into account the relationships between the different components of the supply chain integration and the effect that each one has on the performance indicators of the company (Chang et al., 2007; Flynn et al., 2010a). To help with the development of the proposed future research, in this paper our objectives are the clarification of the constructs, the creation of a measurement scale for the components of the supply chain integration, the validation of these scales and a preliminary study on the effects of a variety of control variables (size of the plant, country, sector and degree of vertical integration) in the values of these scales.

Definitions of integration

According to Flynn (2010a) supply chain integration can be defined as:

> "the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organization processes. The goal is to achieve effective and efficient flows of products and services, information, money and decisions, to provide maximum value to the customer at low cost and high speed"

This is why it is so important to instil confidence amongst all the agents, building long-term relationships, frequent communication, share both profit and risk, and look for effective ways of sharing information, make joint decisions and re-

solve conflicts (Flynn et al., 2010a). There are two main types of integration: external integration and internal integration (Chang et al., 2007; Flynn et al., 2010a; Zhao et al., 2011).

Internal integration refers to the degree to which a company can organise its practices, procedures, information, decisions and conduct in a collaborative and synchronised way between its different areas, to be able to comply with client requirements and effectively interact with its suppliers (Flynn et al., 2010a; Flynn et al., 2010b; Topolsek, 2011; Zhao et al., 2011).External integration refers to the degree to which a company understands the need of its clients and collaborates with clients and/or suppliers to develop inter-organisational strategies and shared practices and processes, so that it manages to satisfy its clients' needs (Flynn et al., 2010a). External integration consists of integration with clients and integration with suppliers (Escrig Tena y Bou-Llusar, 2005; Flynn et al., 2010a; Zhao et al., 2011). According to earlier work, there are close ties between the three basic components of integration (internal, clients and suppliers) (Chang et al., 2007; Escrig Tena y Bou-Llusar, 2005). So it could be construed that internal integration is the precursor to achieving external integration (Bessant et al., 2003; Flynn et al., 2010a; Pagell y LePine, 2002). The use of operational management practices in general, and supply chain integration in particular, are normally affected by national culture, industry, size of the company, the type of company (traditional or World Class) or the degree of vertical integration can affect the type and degree of supply chain integration (Roth et al., 2008)

Method

The aim of this paper is to test the psychometric properties of a survey to identify four constructs of supply chain integration in industrial companies. The test bank of items used to build the survey originate from earlier works (Roth et al., 2008) (Ahmad y Schroeder, 2001; Anderson et al., 1995; Escrig-Tena y Bou-Llusar, 2005; Li et al., 2005; Sakakibara et al., 1993; Zhu et al., 2008). Of these, 4 items have been selected for each construct, aiming to ensure that they are representative of the theoretical definition and that they are not redundant, to avoid the survey being excessively long. The score of the scales is the total of the sum of the items (Table 1).

Our empirical analysis is based on an international sample made up of 266 plants across ten countries (2005-2007 timeframe): Austria, Canada, Finland, Germany, Italy, Japan, Korea, Spain, Sweden and the USA. In each country, the plants were randomly selected from three industries: automotive components, electronics and machinery. The items were targeted at plant accounting managers, direct labour, human resource managers, inventory managers, process engineers, plant managers, quality managers, supervisors and plant superintendents. Items are responded to by at least two different managers/workers in the plant. After that, all

the responses for each item in each plant were averaged to obtain plant items scores.

Table 1 items selected

Scale	Item	Description
Customer integration	It01	We frequently are in close contact with our customers.
	It02	Our customers give us feedback on our quality and delivery performance.
	It03	We strive to be highly responsive to our customers' needs.
	It04	Our customers are actively involved in our product design process.
External Integration	It05	We work as a partner with our customers.
	It06	We work as a partner with our suppliers, rather than having an adversarial relationship.
	It07	We believe that cooperative relationships will lead to better performance than adversarial relationships.
	It08	We believe than an organization should work as a partner with its surrounding community.
Supplier integration	It09	We maintain close communication with suppliers about quality considerations and design changes.
	It10	We maintain cooperative relationships with our suppliers.
	It11	Our customers are actively involved in our product design process.
	It12	We strive to establish long-term relationships with suppliers.
Internal integration	It13	We encourage employees to work together to achieve common goals, rather than encourage competition among individuals.
	It14	Departments in the plant communicate frequently with each other.
	It15	Management works together well on all important decisions
	It16	Generally, speaking, everyone in the plant works well together.

Results

Our sample comprises 266 plants. Of those, 66 companies in Sweden and Germany (24.8%) did not respond to the question on the type of company, 26 (9.8%) did not answer the question on the size of the company (the majority of these in South Korea and the US) and 29 (10.9%) did not respond to the question on the level of vertical integration (once again South Korea and the US are the subsample with the highest number of missing values). The sampling distribution across countries is uniform and there are only major differences to a lesser degree amongst World-class companies in Australia and Finland; a greater proportion of transport companies in Germany; larger companies in Japan and South Korea and a greater degree of vertical integration in Germany, and a lesser degree in Sweden.

Practically all the sample plants answered the 16 items concerning the degree of integration. There were only missing values in 6 items (it05, it07, it13, it14,

it15, it16). And these missing values stem, for the most part, from two plants so there is no point carrying out a detailed analysis of the missing values. For the majority of the items, the distribution of responses has a high average, a typically not very high deviation, negative asymmetry and is leptokurtic. In other words, the majority of responses are in the upper part of the scale (of around 5 and 6 on a seven-level scale). More than half of the items have a "grounding" effect and the minimum values do not tend to cover the whole scale, with a range of responses covering between 3 and 5 different levels of response.

Following internal consistency testing, Item 13 was removed from the internal integration scale given that its correlation with other items on the scale was too low. So is its correlation with the scale as a whole as well as its multiple squared correlation. Similarly, there would be a slight improvement to Chronbach's alpha were it to be eliminated. Average inter item correlations were 0.394 to 0.480, and Chronbach's alpha range from 0.716 to 0.785.

Following this, a multi-trait/multi-item analysis was carried out. To pass the test, the difference between the corrected item-total correlation and the item correlation with other scales should be greater than 0.123. Item05, has more correlation to an factor other than that of the one theoretically assigned to it and its correlation is not sufficiently different in the other two factors. It is therefore an item that could create issues during discriminant validation and will therefore be eliminated from the model. Currently, items it04 and It11 have passed the test.

The results of the exploratory factor analysis with factor extraction techniques using the maximum likelihood method and Varimax criterion under orthogonal rotation, indicate that the sampling adaptation index (0.821) and Bartlett's test of sphericity ($p < 0.000$) are adequate. There are 4 factors with values greater than 1, and which make up for 63.8% of the variance. The items are grouped around the factors proposed by the theory. Factor loadings are all greater than 0.5 in the envisaged factor and have a different of more than 0.3 with regard to the loads in other factors. For this reason, no modifications are made to the scales following analysis.

The final step in the process was the carrying out confirmatory factor analysis to complete checking the convergent and discriminant validation of each scale. We start with the joint measurement model, which is the best representation of the theoretical model where the scales are interlinked (Flynn et al., 2010a). In the first version, two scales had 4 items, and the others 3 items. All the factorial loads were greater than 0.6 with the exception of two items (It04 and It11), which have been eliminated from the definitive version. In the definitive version, all scales have three items, which is why we choose to present the goodness of fit statistics of the model as a whole in stead of doing so scale by scale, as they can not be independently measured when the number of items in the scale is less than 4. The model adjustment statistics are exceptionally good (normed Chi2 robust=1.32; p-value chi2 Satorra= 0.064; CFI=0.98; IFI=0.98; MFI=0.97; RMSA=0.04; GFI= 0.96; AGFI=0.93). All estimations are significant and the standardised factorial loads are all greater than 0.6 (Fig. 1). The extracted variance of the scales are between

0.45 and 0.56 and the compound reliability Cronbach's alpha are in all cases greater than the cut-off value of 0.70. These analyses confirm the convergent validity of the proposed scales. At the same time, the scales also pass the test of variance extracted compared to squared correlations and the confidence interval for correlations.

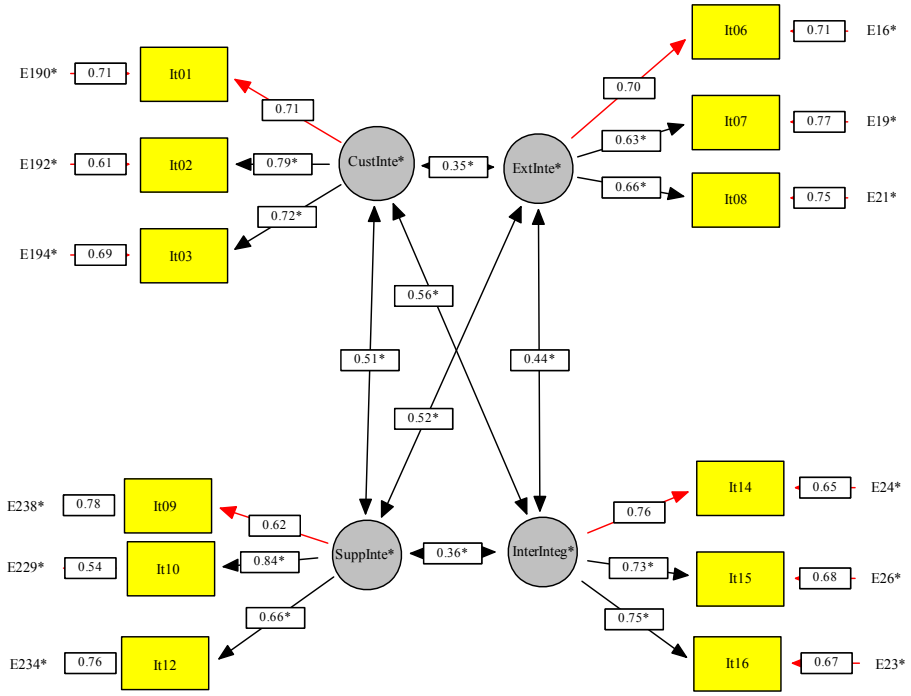

Fig. 1 Standardized estimate joint measurement model

Now that the convergent and discriminant validity of the scales has been shown, we are going to present the scale benchmarks by breaking down the percentiles into 10, 25, 50, 75 and 90% for each scale. Firstly, we will see if the distribution of the sub-samples for each control variable of the supply chain integration scale are significant and if this is the case, we will present an independent benchmark for each of the sub-samples. There are no significant differences in the sub-samples based on the type of company, its size or the level of vertical integration. The general benchmark can therefore be applied to these business subgroups. There are only significant differences by industry for the degree of customer integration between machinery and the other three sectors. Although the differences are significant for the sub-samples of each country, the number of companies available in each sample is two small to be considered representative and therefore does not require the benchmark to be broken down (table 2).

Table 2 scoring benchmark for the supply chain integration scales

		CustIntegr Total	CustIntegr Machinery	CustIntegr Electronics or transportation	ExtIntegr Total	SuppIntegr Total	InterIntegr Total
N	Valid	266	88	178	265	266	265
	Missing	0	0	0	1	0	1
Percentiles	10	15,125	14,469	15,378	15,400	14,654	13,500
	25	16,025	15,476	16,333	16,445	15,660	14,858
	50	17,109	16,667	17,333	17,556	16,667	16,083
	75	18,333	17,788	18,421	18,472	17,667	17,500
	90	19,092	18,744	19,340	19,333	18,333	18,167

Conclusions

This research paper provides an overview of the latest chain supply integration scales and expresses the need to formulate measurement instruments that allow one to identify the degree of use of each of the four constructs in companies (internal integration, external integration, integration with clients and integration with suppliers).

Starting out with a set of items, created especially for this research, 4 scales are proposed, and are subsequently validated using a broad sample. The definitive scales show excellent psychometric properties, although they do point to certain limitations such as, for example, the generalization of other industrial sectors (given that the sample consists of companies from only three sectors); or that the range of responses are concentrated in the upper part of the scale. This behaviour could stem from the characteristics of the sectors chosen for the sample, in which case it would be desirable to test out these scales in the future using a broader sampling and with plants from different sectors. In this way, the benchmark could be extended to be able to analyse differences by country or by sector (if these were available). Developing similar scales focusing on service companies that have their own set of characteristics when it comes to understanding and applying supply chain integration would be required.

The outcomes of this paper have obvious academic implications as it responds to requests expressed in recently published articles in this field, which asked for a clearer and more concise designation of the supply chain integration measurement scales. In this way, more reliable and accurate data could be taken to analyse the relations between these constructs with other variables of interest to the academic and professional fields, such as for example the outcomes or production efficiency. From a professional perspective, this paper contributes to providing scales that are valid as a diagnostic tool for best practices, as well as providing a benchmark with which to compare the score for each individual plant against a collec-

tion of industrial companies from the machinery, electronics and transportation sectors.

References

Ahmad, S.; Schroeder, R. G. (2001). The impact of electronic data interchange on delivery performance. Production and Operations Management, Vol. 10, nº. 1, pp. 16-30.

Alfalla-Luque, R.; Medina-López, C. (2009). Supply Chain Management: Unheard of in the 1970s, core to today's company. Business History, Vol. 51, nº. 2, pp. 202-221.

Anderson, J. C.; Rungtusanatham, M.; Schroeder, R. G.; Devaraj, S. (1995). A path analytic model of a theory of quality management underlying the Deming Management method: Preliminary empirical findings. Decision Sciences, Vol. 26, nº. 5, pp. 637-658.

Bessant, J.; Kaplinsky, R.; Morris, M. (2003). Developing capability through learning networks. International Journal of Technology Management & Sustainable Development, Vol. 2, nº. 1, pp. 19-38.

Chang, W. L.; Ik-Whan, G. K.; Dennis, S. (2007). Relationship between supply chain performance and degree of linkage among supplier, internal integration, and customer. Supply Chain Management: An International Journal, Vol. 12, nº. 6, pp. 444-452.

Escrig Tena, A. B.; Bou-Llusar, J. C. (2005). A model for evaluating organizational competencies:An application in the context of a quality management initiative. Decision Sciences, Vol. 36, nº. 2, pp. 221-257.

Escrig-Tena, A.; Bou-Llusar, J. C. (2005). A model for evaluating organizational competencies: An application in the context of a quality management initiative. Decision Sciences, Vol. 36, nº. 2, pp. 221-257.

Flynn, B. B.; Huo, B.; Zhao, X. (2010a). The impact of supply chain integration on performance: A contingency and configuration approach. Journal of Operations Management, Vol. 28, pp. 58-71.

Flynn, B. B.; Wu, S. J.; Melnyk, S. A. (2010b). Operational capabilities: Hidden in plain view. Business Horizons, Vol. 53, pp. 247-256.

Li, S. H.; Rao, S. S.; Ragu-Nathan, T. S.; Ragu-Nathan, B. (2005). Development and validation of a measurement instrument for studying supply chain management practices. Journal of Operations Management, Vol. 23, nº. 6, pp. 618-641.

Pagell, M.; LePine, J. A. (2002). Multiple case studies of team effectiveness in manufacturing organizations. Journal of Operations Management, Vol. 20, nº. 5, pp. 619-639.

Roth, A. V.; Schroeder, R. G.; Huang, X.; Kristal, M. M. (2008). Handbook of metrics for research in Operations Management multi-item measurement scales and objective items SAGE publications

Sakakibara, S.; Flynn, B. B.; Schroeder, R. G. (1993). A framework and measurement instrument for just-i n-time manufacturing. Production and Operations Management, Vol. 2, nº. 3, pp. 177-194.

Topolsek, D. (2011). The impact of collaboration or collaborative behaviour on the level of internal integration: Case study of Slovenian retailers and motor vehicle repair companies. African Journal of Business Management, Vol. 5, nº. 26, pp. 10345-10354.

Zhao, X.; Huo, B.; Selen, W.; Yeung, J. H. Y. (2011). The impact of internal integration and relationship commitment on external integration. Journal of Operations Management, Vol. 29, nº. 1-2, pp. 17-32.

Zhu, Q.; Sarkis, J.; Lai, K. h. (2008). Confirmation of a measurement model for green supply chain management practices implementation. International Journal of Production Economics, Vol. 111, nº. 2, pp. 261-273.