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Supply chain integration scales validation and benchmark values

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Abstract:

Purpose: The clarification of the constructs of the supply chain integration (clients, suppliers, external and internal), the creation of a measurement instrument based on a list of items taken from earlier papers, the validation of these scales and a preliminary benchmark to interpret the scales by percentiles based on a set of control variables (size of the plant, country, sector and degree of vertical integration).

Design/methodology/approach: Our empirical analysis is based on the HPM project database (2005-2007 timeframe). The international sample is made up of 266 plants across ten countries: Austria, Canada, Finland, Germany, Italy, Japan, Korea, Spain, Sweden and the USA. In each country. We analized the descriptive statistics, internal consistency testing to purify the items (inter-item correlations, Cronbach's alpha, squared multiple correlation, corrected item-total correlation), exploratory factor analysis, and finally, a confirmatory factor analysis to check the convergent and discriminant validity of the scales. The analyses will be done with the SPSS and EQS programme using the maximum likelihood parameter estimation method.

Findings: The four proposed scales show excellent psychometric properties.

Research limitations/implications: with a clearer and more concise designation of the supply chain integration measurement scales more reliable and accurate data could be taken to analyse the relations between these constructs with other variables of interest to the academic l fields.

Practical implications: 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 collection of industrial companies from the machinery, electronics and transportation sectors.

Originality/value: supply chain integration may be a major factor in explaining the performance of companies. The results are nevertheless inconclusive, 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 as to the variety of the scales used.

Keywords: scale validation, questionnaire, reliability, validity, psichometric properties, supply chain integration

1. Introduction

The concept of supply chain integration is of great interest for academics working in operational management (Zhao, Huo, Selen & Yeung, 2011; Flynn, Huo & Zhao, 2010). One of the main reasons is that it greatly influences the competitive advantage of companies (Flynn et al., 2010; Chang, Ik-Whan & Dennis, 2007; Alfalla-Luque, Medina-Lopez & Schrage, 2012). 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 (Roth, Schroeder, Huang & Kristal, 2008; Zhu, Sarkis & Lai, 2008; Li, Rao, Ragu-Nathan & Ragu-Nathan, 2005; Flynn et al., 2010, Alfalla-Luque, Medina-Lopez & Dey, 2012). 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 (Zhao et al., 2011; Chang et al., 2007; Flynn et al., 2010).

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 (Chang et al., 2007; Flynn et al., 2010; Flynn, Wu & Melnyk, 2010; Narasimhan & Kim, 2002; Topolsek, 2011; Zhao et al., 2011; Alfalla-Luque & Medina-López, 2009; Carter, Sanders & Dong, 2008; Kaynak & Hartley, 2008; Li, Ragu-Nathan, Ragu-Nathan & Subba Rao, 2006). 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., 2010; Narasimhan & Kim, 2002; Zhao et al., 2011).

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.

2. Definitions of integration

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

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 (Zhao et al., 2011; Topolsek, 2011; Flynn et al., 2010; Flynn et al., 2010).

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., 2010). External integration consists of integration with clients and integration with suppliers (Flynn et al., 2010; Zhao et al., 2011; Escrig Tena & Bou-Llusar, 2005).

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 & Bou-Llusar, 2005). So it could be construed that internal integration is the precursor to achieving external integration (Flynn et al., 2010; Pagell & LePine, 2002; Bessant, Kaplinsky & Morris, 2003; Harrison & Van Hoek, 2005; Cagliano, Caniato & Spina, 2006).

3. Control variables for supply chain integration

The use of operational management practices in general, and supply chain integration in particular, are normally affected by national culture, meaning that it is quite common to come across research where the country in which the plant is located explains to a certain extent the degree of use of supply chain integration (Oliver & Delbridge, 2002; Hofstede, 1998; Zhao et al., 2011; Pagell, Katz & Sheu, 2005). Another variable that often comes up is the sector (MacDuffie & Helper, 1997; Bruce, Daly & Towers, 2004; Bayraktar, Jothishankar, Tatoglu & Wu, 2007; Oliver & Delbridge, 2002; Roth et al., 2008; Martinez Jurado & Moyano Fuentes, 2011). There are also references to the fact that integration is associated with the size of the company (Underhill, 2001; Roth et al., 2008; Zhao et al., 2011). And finally, the degree of vertical integration can affect the type and degree of supply chain integration (Roth et al., 2008; Hayes & Wheelwright, 1984).

4. Method

The aim of this paper is to test the psychometric properties of a questionnaire to identify four constructs of supply chain integration in industrial companies.

We begin looking at a reflective model, where the items of the scales are estimators conditioned by a construct that can not be directly observed. The items therefore reflect this construct and are interchangeable, with the result that any group of these items will provide an estimation equivalent to the phenomenon of interest (Hair, Anderson, Tatham & Black, 1999; Brown, 2006; Byrne, 2006; Baxter, 2009).

The test bank of items used to build the survey originate from earlier works (Roth et al., 2008). Of these, 4 items have been selected for each construct, aiming to ensure that they are representative of the theoretical definition, used in recent papers, 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 the HPM project database, the data for which was collected during the third round of this project (2005-2007 timeframe) by an international team of researchers. As a whole, the international sample is made up of 266 plants across ten countries: 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. A stratified sampling design was used to obtain an approximately equal number of plants for each industry-country combination. 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.

Scale	Item	Description	Used in
Customer integration	It01	We frequently are in close contact with our customers.	(Kim, 2009; Narasimhan & Kim, 2002; Sezen, 2008; Stank, Keller & Daugherty, 2001; Swink & Nair, 2007; Tan, Lyman & Wisner, 2002; Vickery, Jayaram, Droge & Calantone, 2003; Wong & Boon-Itt, 2008; Vachon & Klassen, 2007; Germain & Iyer, 2006; Hsu, Kannan, Tan & Leong, 2008; Flynn et al., 2010; Thun, 2010)
	It02	Our customers give us feedback on our quality and delivery performance.	(Kim, 2009; Narasimhan & Kim, 2002; Sezen, 2008; Stank et al., 2001; Swink & Nair, 2007; Tan et al., 2002; Vachon & Klassen, 2007; Hsu et al., 2008; Flynn et al., 2010; Thun, 2010)
	It03	We strive to be highly responsive to our customers' needs.	(Kannan & Tan, 2005; Sezen, 2008; Swink & Nair, 2007; Tan et al., 2002; Vachon & Klassen, 2007; Hsu et al., 2008; Kulp, Lee & Ofek, 2004; Thun, 2010)
	It04	Our customers are actively involved in our product design process.	(Tan et al., 2002; Vachon & Klassen, 2007; Hsu et al., 2008; Kulp et al., 2004)
External Integration	It05	We work as a partner with our customers.	(Stank et al., 2001; Tan et al., 2002; Wong & Boon-Itt, 2008; Hsu et al., 2008; Sanders, 2005; Danese, Formentini, Romano & Bortolotti, 2010)
	It06	We work as a partner with our suppliers, rather than having an adversarial relationship.	(Kim, 2009; Narasimhan & Kim, 2002; Wong & Boon-Itt, 2008; Hsu et al., 2008; Flynn et al., 2010; Sanders, 2005)
	It07	We believe that cooperative relationships will lead to better performance than adversarial relationships.	(Swink & Nair, 2007; Hsu et al., 2008; Bagchi, Ha, Skjoett-Larsen & Soerensen, 2005; Giménez & Ventura, 2003; Kannan & Tan, 2005)
	It08	We believe than an organization should work as a partner with its surrounding community.	(Sezen, 2008; Hsu et al., 2008; Kannan & Tan, 2005)
Supplier integration	It09	We maintain close communication with suppliers about quality considerations and design changes.	(Kannan & Tan, 2005; Kim, 2009; Sanders & Premus, 2005; Sezen, 2008; Stank et al., 2001; Swink & Nair, 2007; Tan et al., 2002; Wong & Boon-Itt, 2008; Vachon & Klassen, 2007; Hsu et al., 2008; Flynn et al., 2010)
	It10	We maintain cooperative relationships with our suppliers.	(Sanders & Premus, 2005; Stank et al., 2001; Tan et al., 2002; Vickery et al., 2003; Wong & Boon-Itt, 2008; Vachon & Klassen, 2007; Hsu et al., 2008; Sanders, 2005; Flynn et al., 2010; Thun, 2010)
	It11	Our customers are actively involved in our product design process.	(Kim, 2009; Koufteros, Cheng & Lai, 2007; Swink & Nair, 2007; Vachon & Klassen, 2007; Hsu et al., 2008; Kulp et al., 2004; Flynn et al., 2010)
	It12	We strive to establish long-term relationships with suppliers.	(Stank et al., 2001; Sanders, 2005; Flynn et al., 2010; Bagchi et al., 2005; Briscoe & Dainty, 2005)
Internal integration	It13	We encourage employees to work together to achieve common goals, rather than encourage competition among individuals.	(Stank et al., 2001; Wong & Boon-Itt, 2008; Germain & Iyer, 2006; Flynn et al., 2010; Giménez & Ventura, 2003)
	It14	Departments in the plant communicate frequently with each other.	(Kim, 2009; Sanders & Premus, 2005; Stank et al., 2001; Vickery et al., 2003; Wong & Boon-Itt, 2008; Germain & Iyer, 2006; Flynn et al., 2010; Giménez & Ventura, 2003)
	It15	Management works together well on all important decisions	(Narasimhan & Kim, 2002; Sanders & Premus, 2005; Germain & Iyer, 2006; Giménez & Ventura, 2003)
	It16	Generally, speaking, everyone in the plant works well together.	(Sanders & Premus, 2005; Wong & Boon-Itt, 2008; Giménez & Ventura, 2003)

Table 1. Items selected in the survey

We will start by analyzing the descriptive statistics, paying close attention to missing values, skip patterns, range of response values, asymmetry and kurtosis (Viladrich Segués & Doval Dieguez, 2011; Doval Dieguez & Viladrich Segués, 2011).

We will then carry out internal consistency testing to purify the items (inter-item correlations, Cronbach's alpha, squared multiple correlation, corrected item-total correlation). The set of items that pass the internal consistency testing will be analysed using exploratory factor analysis with maximum likelihood and varimax rotation, to verify if each of the items has high loads on the predicted scales, and with a multi-trait/multi-item analysis to see the discriminant validity (Doval Dieguez & Viladrich Segués, 2011). And finally, a confirmatory factor analysis will be carried out using robust estimators, which will allow us to check the convergent and discriminant validity of the scales. This model incorporates the correlations of all the scales amongst themselves, given that certain theoretical evidence would appear to show that there is a certain overlapping between the constructs and that their correlations should therefore be taken into consideration (Flynn et al., 2010).

Convergent validity will be tested using four criteria. The first is that statistics of the robust model's goodness of fit are appropriate (P-value Robust Chi2 > 0.05; normed Chi2 < 5; CFI > 0.90; IFI > 0.90; MFI > 0.90; GFI > 0.85; RMSEA < 0.08) (Hair et al., 1999; Sila, 2007; Spreitzer, 1995; Tari, Molina & Castejón, 2007; Ullman & Bentler, 2004). Secondly, composite reliability will be checked as being over 0.7 (Hair et al., 1999). Thirdly, it will be checked that the Cronbach's alpha are over 0.70 (Hair et al., 1999; Lin, 2006). The fourth criterion will test whether variance extracted is over 40% (Hair et al., 1999). Discriminant validity will be checked using the test of variance extracted compared to squared correlations (Fornell & Larcker, 1981; Hair et al., 1999; Farrell, 2010) and the confidence interval for correlations (Anderson & Gerbing, 1988; Bagozzi, 1994). The analyses will be done with the SPSS and EQS programme using the maximum likelihood parameter estimation method (Ullman & Bentler, 2004).

5. 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 sub-sample 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 (Table 2).

		Industry			Plant size			Vertical integration			
Count.	**Tot**	**Electr.**	**Machi.**	**Trans.**	**50 -250**	**251 -500**	**> 500**	**Not**	**Low**	**Med.**	**High**
Austria	21	10	7	4	10	3	5	0	2	12	5
Finland	30	14	6	10	15	10	5	1	5	16	6
Germany	41	9	13	19	12	13	16	0	8	14	17
Italy	27	10	10	7	14	6	7	2	4	14	6
Japan	35	10	12	13	5	6	23	0	9	13	11
South Korea	31	10	10	11	2	3	14	1	1	16	4
Spain	28	9	9	10	12	8	7	0	7	9	9
Sweden	24	7	10	7	10	8	5	2	7	13	0
USA	29	9	11	9	6	8	7	1	8	8	6
Total	266	88	88	90	86	65	89	7	51	115	64

Table 2. Composition of the sample of companies

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 are 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 (See Table 3).

Item	N	Range	Minimum	Maximum	Average	Typ. Dev.	Asymmetry	Kurtosis
It01	266	5.33	1.67	7.00	5.3429	0.77076	-0.738	1.747
It02	266	4.00	3.00	7.00	5.6873	0.70058	-0.328	0.037
It03	266	3.00	4.00	7.00	6.0724	0.51030	-0.734	0.957
It04	266	4.67	2.00	6.67	4.6142	0.84354	-0.142	-0.288
It05	265	4.00	3.00	7.00	5.5844	0.70905	-0.701	0.680
It06	266	4.00	3.00	7.00	5.6444	0.68590	-0.911	1.352
It07	265	3.17	3.83	7.00	6.0305	0.60557	-0.781	0.835
It08	266	2.89	4.11	7.00	5.7789	0.56771	-0.315	-0.084
It09	266	3.81	2.93	6.73	5.2711	0.66239	-0.634	0.248
It10	266	3.60	3.40	7.00	5.5506	0.56121	-0.564	1.027
It11	266	4.46	1.88	6.33	4.5870	0.80275	-0.408	0.038
It12	266	3.50	3.50	7.00	5.7113	0.60831	-0.497	0.319
It13	265	3.11	3.89	7.00	5.8400	0.56874	-0.690	1.022
It14	265	4.00	3.00	7.00	5.3782	0.72600	-0.452	0.332
It15	265	5.33	1.67	7.00	5.1967	0.77881	-0.852	1.413
It16	265	4.00	3.00	7.00	5.4385	0.76041	-0.626	0.431

Table 3. Descriptive statistics

Following internal consistency testing (Tables 4 and 5), 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. This would indicate that the item be eliminated. The external integration scale for It05 is not related to the other items and this penalizes the statistics. The item should probably be eliminated if it does not pass the next stages of analysis. Were it be eliminated, the average correlations between items would slightly improve (0.462 with a minimum of 0.447 and a maximum of 0.472), and the Cronbach's Alpha would remain at 0.72. On the other scales, the items with the poorest results are It04 and It11, which have the squared multiple correlation and would result in a slight increase to Cronbach's Alpha were they to be eliminated. This is the same case for It05, whereby it remains until subsequent analysis determined if it should be eliminated or not.

	Average	Minimum	Maximum	Alpha	Lim Inf IC Alfa	Lim Inf IC Alfa	No. elements
Customer integration	0.480	0.283	0.574	0.775	0.727	0.816	4
External Integration	0.394	0.299	0.472	0.716	0.656	0.768	4
Supplier integration	0.448	0.285	0.568	0.753	0.700	0.798	4
Internal integration	0.550	0.516	0.582	0.785	0.765	0.826	3

Table 4. Inter-item correlations and Cronbach's alpha

Following this, a multi-trait/multi-item analysis was carried out (Table 5). 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 -2* standard error (Doval Dieguez & Viladrich Segués, 2011)-. Item05, earmarked following earlier analysis as potentially having problems, has more correlation to an access other than that of the one theoretically assigned to it and its correlation is not sufficiently different in the other two axes. 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 (Table 6), 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.

item	Squared multiple correlation	Cronbach's Alpha if the element is eliminated	Customer integration	External Integration	Supplier integration	Internal integration
It01	0.435	0.676	**0.656**	0.310**	0.284**	0.334**
It02	0.472	0.673	**0.668**	0.330**	0.389**	0.337**
It03	0.370	0.752	**0.539**	0.309**	0.288**	0.390**
It04	0.293	0.770	**0.510**	0.215**	0.248**	0.241**
It05	0.169	0.717	0.494**	**0.409**	0.308**	0.297**
It06	0.331	0.614	0.128*	**0.564**	0.381**	0.243**
It07	0.298	0.642	0.232**	**0.525**	0.249**	0.262**
It08	0.301	0.639	0.201**	**0.537**	0.315**	0.254**
It09	0.406	0.652	0.336**	0.294**	**0.624**	0.209**
It10	0.435	0.667	0.290**	0.402**	**0.620**	0.253**
It11	0.310	0.736	0.253**	0.318**	**0.507**	0.199**
It12	0.335	0.726	0.300**	0.304**	**0.489**	0.229**
It14	0.424	0.680	0.328**	0.274**	0.172**	**0.651**
It15	0.361	0.735	0.346**	0.315**	0.256**	**0.599**
It16	0.394	0.710	0.332**	0.312**	0.289**	**0.622**

Table 5. In bold, the corrected item-total correlation (as this is the prescribed scale for the item), the rest of the correlations are routine Pearson correlations

Item	Factor1	Factor2	Factor3	Factor4
It01	**0.725**	0.121	0.160	0.106
It02	**0.738**	0.256	0.146	0.092
It03	**0.594**	0.149	0.247	0.129
It04	**0.560**	0.124	0.112	-0.001
It06	-0.029	0.299	0.122	**0.659**
It07	0.151	0.066	0.131	**0.670**
It08	0.094	0.213	0.124	**0.588**
It09	0.198	**0.725**	0.060	0.074
It10	0.147	**0.674**	0.109	0.255
It11	0.106	**0.585**	0.085	0.140
It12	0.183	**0.526**	0.107	0.163
It14	0.192	0.025	**0.768**	0.100
It15	0.168	0.188	**0.686**	0.130
It16	0.218	0.119	**0.638**	0.181

Table 6. Rotated factor matrix· Extraction method: Maximum likelihood

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., 2010). 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= .064; CFI= .98; IFI=.98; MFI= .97; RMSA= .04; GFI= .96; AGFI= .93). All estimations are significant and the standardised factorial loads are all greater than 0.6 (Figure 1). The extracted variance of the scales is between .45 and .56 and the compound reliability Cronbach’s alpha are in all cases greater than the cut-off value of .70 (Table 7). 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 (Table 7).

	Num Items	Alpha	EVA	Comp. Rel.	Cust. Int.	Ext. inte.	Supp. Int.	Intern. Int.
Customer integration	3	0.77	0.55	0.79	**0.74**	0.35	0.52	0.56
External Integration	3	0.71	0.45	0.71	(0.30,0.41)	**0.67**	0.52	0.44
Supplier integration	3	0.74	0.51	0.75	(0.47,0.56)	(0.48,0.57)	**0.71**	0.36
Internal integration	3	0.79	0.56	0.79	(0.49,0.62)	(0.39,0.49)	(0.31,0.40)	**0.75**

Table 7. Results of confirmatory factor analysis. In the first four columns: Number of items of the scale, Cronbach’s alpha, Extracted Variance and compound reliability of each of the scales. In the last four columns, in the upper diagonal are the correlations between scales; in the lower diagonal, the 95% confidence interval for the correlation between scales and, in bold on the diagonal, the square root of the extracted variance

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 (Table 8). 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 (Doval Dieguez & Viladrich Segués, 2011).

There are no significant differences in the sub-samples based on its size or the level of vertical integration. The general benchmark can therefore be applied to these business sub-groups. 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.

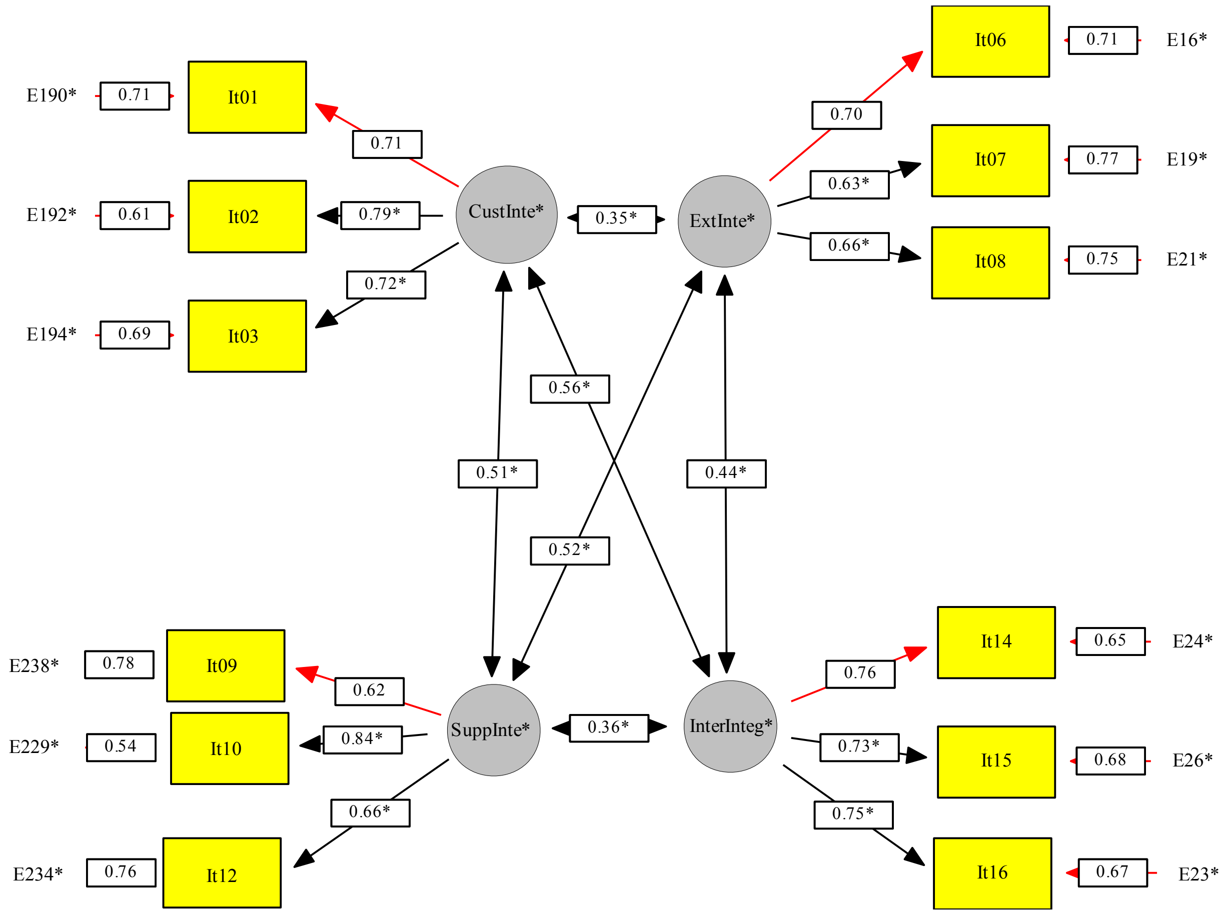

Figure 1. Standardized estimate joint measurement model

		CustIntegr Total	CustIntegr Machinery	CustIntegr Electr. or transp.	ExtIntegr Total	SuppIntegr Total	InterIntegr Total
N	Valid	266	88	178	265	266	265
	Missing	0	0	0	1	0	1
Percentiles	10	15.1	14.4	15.3	15.4	14.6	13.5
	25	16.0	15.4	16.3	16.4	15.6	14.8
	50	17.1	16.6	17.3	17.5	16.6	16.0
	75	18.3	17.7	18.4	18.4	17.6	17.5
	90	19.0	18.7	19.3	19.3	18.3	18.1

Table 8. Scoring benchmark for the supply chain integration scales

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

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