Supply chain integration obtained through uniquely labelled goods: A survey of Swedish manufacturing industries

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Supply chain integration obtained through uniquely labelled goods

A survey of Swedish manufacturing industries

Henrik Pålsson and Ola Johansson

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Abstract

Purpose – This paper aims to examine the use of unique identities (through radio frequency identification technology, bar codes and “human-readable” labels) on packages and load carriers in Swedish manufacturing industries. The purpose is to investigate drivers behind the adoption, the perceived improvements and visions for the coming 2-5 years. It also covers different methods for reading the identities, locations of identification in the supply chain and how the acquired information is utilised.

Design/methodology/approach – The paper uses the survey method. The survey instrument was developed in co-operation with an expert group consisting of both researchers and industry representatives. The data were analysed using multivariate techniques.

Findings – The analysis shows that there are a number of distinct clusters of companies with similar drivers for the adoption of unique identification. Characteristics of companies in these clusters are described and compared. The analysis clarifies the essential roles of integration and information sharing to obtain logistical improvements.

Research limitations/implications – To provide a more robust scientific justification of the survey results, in-depth case studies should be carried out and similar studies could be conducted in other countries and/or industries.

Practical implications – Managers intending to implement unique identities need to understand the importance of having the right organisational motivation to succeed. Firms already using unique identities should note that the greater the integration and information sharing, the greater the number of improvements which could be obtained.

Originality/value – The study shows that there are links between the drivers behind the adoption of unique identities and the level of integration and improvements achieved. It also provides the current status of different identification methods in Swedish manufacturing industries.

Keywords Barcodes, Product identification, Information strategy, Integration, Sweden, Manufacturing industries

Paper type Research paper

1. Introduction

Integration has been defined as combining and co-ordinating separate parts or elements into a unified whole. In today’s global economy, with ever-increasing competition, the manufacture and supply of goods to the customer has become increasingly complex, and without efficient and effective systems of communication and co-ordination, it will be difficult to identify problems and respond quickly to a change in customer demand. “The signs are clearly pointing to a future where it will be the extent and quality of supply chain integration that will determine marketplace performance” (Christopher, 1998, p. 232).
Integration is, however, a wide concept encompassing many different aspects of co-ordinating separate parts of a supply chain into a cohesive whole. Consequently, the phenomenon has been defined in a number of different, albeit interrelated ways. Pagell (2004) features a review of different definitions of integration. Although a large number of definitions can be found in literature, they usually share common themes and include elements such as co-operation, co-ordination, interaction and collaboration (Ellinger et al., 2000; Frohlich and Westbrook, 2001; Kahn and Mentzer, 1996). The definitions provided in literature, however, are generally high-level constructs, and as such, are difficult to measure or assess. Several attempts have been made to operationalise the constructs to enable empirical measurements of integration. Some authors have chosen to focus on behavioural aspects, e.g. Ellinger et al. (2000), who suggest three behavioural dimensions of integration:

1. collaboration, which is defined as informal behaviours based on resource and information sharing;
2. consultation, defined as mandatory, bidirectional interactions requiring personal contacts; and
3. information exchange, i.e. formal, structured, documented interactions which do not involve personal contacts.

Others, like Larson (1994, p. 155), suggest that inter-organisational integration is “measured as (1) co-operative behaviour between purchasing and key supplier firm departments, and (2) co-operative attitudes”. A second group of authors, e.g. Dawe (1994), Gustin and Daugherty (1995) and Lee and Whang (2000), focus on information sharing, information availability and IS system performance across inter-departmental or inter-organisational borders as signs of integration.

Frohlich and Westbrook (2001) take a similar path and assess the level of integration through signs of integrative activities such as access to planning systems, sharing of production plans, joint EDI (electronic data interchange) access/networks, etc. but they also include common use of third-party logistics, standardisation of logistical equipment or containers, and packaging customisation. The inclusion of packaging aspects is rare in integration research. Traditionally, packaging has been viewed as a protective component only, especially in business to business, rather than something which can create value throughout the supply chain. While the importance of integration is not in doubt, relevant literature lacks a comprehensive study of how packaging and, more importantly, the common information interface packaging provides, can support manufacturing and distribution efficiency by integrating internal and external functions within a supply chain.

A key component for achieving integration through packaging is the use of unique identities on items. Unique identities can be realised by means of, e.g. labels, bar codes or radio frequency identification (RFID) tags which can be applied to packaging. Bar codes and RFID tags may be read using automatic data collection, which is often superior compared to “human-readable” labels. The error rate for human data entry has been reported to be 1 in 300, while the corresponding level for automatic data collection is radically lower (Smith and Offodile, 2002). In addition to increased information accuracy, automatic data collection may also reduce time for data entry and reduce paperwork (Singer, 1998). However, the characteristics of technologies for automatic data collection differ. Regarding performance, RFID has a number of
advantages over bar codes. For instance, it does not require line of sight, the reading distance can be longer, reading is faster and RFID can have both read and write capabilities. The additional benefits of RFID over bar codes have been reported to save labour costs compared to the manual scanning of bar codes, and to reduce inventory, shrinkage and out-of-stock situations through the higher visibility offered by RFID (Lee and Ozer, 2007). On the other hand, bar codes have one major advantage over RFID; they are usually cheaper than RFID tags.

Unique identities can be applied to different levels of packaging; primary packaging (usually a sales unit or item level), secondary packaging (e.g. a case) and tertiary packaging (e.g. a pallet for bulk handling of goods). Regardless of packaging level, the use of unique identities must certainly be complemented with information systems and infrastructure to register the identities and store data about the whereabouts and condition of items in the supply chain. However, taking a packaging perspective and focusing on the use of unique identities to investigate supply chain integration represent, to the best of the authors' knowledge, a new approach and one which may provide new insights into supply chain integration.

Thus, this paper examines the use of unique identities (through RFID technology, bar codes and “human-readable” labels) applied to packages and load carriers in Swedish manufacturing industries. The purpose of the paper is to investigate drivers behind the adoption, as well as the perceived improvements and visions for the coming 2-5 years. It also covers the use of different methods for reading the identities, locations of identification in the supply chain and how the acquired information is utilised.

The paper is structured in the following way. First, we provide the methodology, including the survey instrument, the respondents and the data collection process. Then, the results of the survey and the data analysis are presented, including descriptive statistics, integration levels, logistical improvements, and information sharing for different types of companies, as well as visions for the future. Subsequently, we discuss our results from a more general perspective in relation to findings in current literature. Finally, we draw conclusions as we highlight the main results and their implications and make suggestions for future research.

2. Methodology

In order to ensure an overall view of the usage of unique identities, a postal survey of Swedish manufacturing firms was conducted across a wide range of industries.

2.1 Instrument

The survey instrument was developed in four stages. In the first stage, literature regarding supply chain integration and RFID technology was reviewed. This review facilitated identification of focus areas for the survey. Supply chain integration was selected, since the use of unique identification of goods along the supply chain can be seen as a sign of integration. RFID technology, on the other hand, is considered by authors in current logistics literature to play a key role for obtaining unique identification of goods. Consequently, current literature on RFID technology presents many potential benefits of unique identities which contributed to the survey development. In the second stage, a draft questionnaire with 14 question areas was developed. To gain feedback about the structure and clarity of the questionnaire, it was pre-tested on a group of academics. Based on the feedback, the questionnaire
was modified; a number of questions were rephrased, added or deleted. The revised questionnaire was then tested on a group of representatives from industry. This also resulted in further modifications; the survey was reorganised, a few questions were deleted and some questions were rephrased. The final version of the survey instrument included 14 question areas with three to 19 questions per area. The initial questions considered type and registration location of unique identities on a nominal scale. The other questions were based on a five-point Likert scale covering demographic data, information sharing, results and visions obtained through unique identities. The response alternatives ranged from strongly disagree to strongly agree, with a neutral alternative in the middle.

2.2 Respondents
The survey was directed at logistics managers in manufacturing companies in Sweden. Several industries were selected to obtain a broad overview of the use of unique identities across different businesses, and manufacturing firms were selected because these were expected to have both complex internal and external material flows. To limit the study, small companies with fewer than 100 employees were not considered. The total population includes 715 companies in nine different manufacturing industries with 100 or more employees. The sample size and distributions between different groups of company size and industries were discussed with a statistical expert. This led to the conclusion that company size and type of industry could affect survey results. Therefore, a stratified sample was used to avoid disequilibrium among the groups. The companies were divided into three groups according to size; small, medium-sized, and large companies (Table I). All large companies, i.e. those with 500 or more employees, were included in the sample. Then, 40 per cent of the medium-sized companies with 200-499 employees were systematically selected, and every one small company in four, i.e. with 100-199 employees, was systematically selected to be included in the sample. Thereby, a systematic, stratified sample with approximately equal group sizes was obtained. In total, 310 firms were selected, which equals a sample size of 43 per cent of the total population (manufacturing industries).

2.3 Data collection
The data collection took place in February and March 2008. The logistics managers of the selected firms were posted questionnaires accompanied by an explanatory covering letter and a pre-paid postage return envelope. The covering letter explained the research, asked for the respondents’ help in completing the survey and promised a prompt copy of the results of the study to encourage participation (Frohlich, 2002). A unique code was attached to each questionnaire to facilitate follow-up. The use of the code was explained to the respondents and the covering letter emphasised the respondents’ confidentiality. Reminder letters including the same package were sent out to non-respondents two weeks after the first questionnaire was posted. Follow-up telephone calls, conducted one week after the reminder mail, were made to obtain additional responses. The 152 responses received represent an overall response rate of 49.0 per cent. Out of the responses, all but one could be used for subsequent data processing. Table I provides frequency distributions of number of employees and industry. A majority of the non-respondents were reached by phone during the follow-up calls. The reason cited most often for non-response was lack of time, followed
by company policy. To check for non-response bias, early responses from the first group of questionnaires sent by post were compared to late responses obtained after follow-up calls. No statistically significant differences were found, which indicates the absence of non-response bias (Armstrong and Overton, 1977).

3. Results
The data are analysed in four steps. First, descriptive statistics of individual questions are reviewed. Graphical data exploration is used to assess overall practices and results of using unique identities provided by the respondents. The plots indicate homoscedasticity for all variables, i.e. the variables exhibit equal levels of variance. Second, a factor analysis is conducted to identify dimensions which may explain drivers behind the adoption of unique identities. A cluster analysis is then performed to group the respondents in terms of their drivers for implementation. Finally, the clusters are assessed and differences are analysed.

3.1 Descriptive statistics
The initial question in the questionnaire is a screening question regarding whether the company uses unique identities on products or load carriers. Of the respondents, 57 stated that they do not. Table II displays the use of unique identities versus company size. Unsurprisingly, it seems to be more common for large companies to use unique
identities, compared to smaller ones. A $\chi^2$ test shows that the differences between the groups are statistically significant with 95 per cent confidence.

Based on the usage of unique identities, the data material was divided into two parts. The remainder of this chapter, unless otherwise stated, is based on data from the group which uses unique identities. Of the respondents, 71 per cent using unique identities state that they use them on primary packaging or item level, 67 per cent use unique identities on secondary packaging or case level, while 66 per cent use unique identities on tertiary packaging or load carrier level. Of the respondents, 32 per cent state that they use unique identities on all three levels of packaging. Bar coding was the most frequently used method (84 per cent) for assigning unique identities to packaging, followed by labels with “human-readable” text or numeric strings (56 per cent). Only seven respondents (7 per cent) stated that they use RFID tags to achieve unique identities on packaging or products. Another 23 per cent of all the respondents (152), however, state that they consider implementing RFID in the future and 8 per cent report that they have performed a pilot study using RFID technology.

The location where the unique identities are read and registered was also assessed (Figure 1). It seems that downstream use of unique identities is slightly more common than upstream use. Internal use seems to dominate, especially for keeping track of finished goods inventory.

Similar patterns can be seen in the drivers for implementing unique identities. Improved traceability scores the highest, while reduction of theft or counterfeiting seems to be of much less concern among respondents (Table III). Improved data

<table>
<thead>
<tr>
<th>Company size (no. of employees)</th>
<th>Unique labelling</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Small (100-199)</td>
<td>16</td>
</tr>
<tr>
<td>Medium-sized (200-499)</td>
<td>29</td>
</tr>
<tr>
<td>Large (above 499)</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
</tr>
</tbody>
</table>

Table II. Companies using unique identities

Figure 1. Registration structure of uniquely labelled products and load carriers
capture in terms of reduced number of errors and increased efficiency score highly, as well as improved inventory control and delivery service. Again, internal co-ordination seems to be more important than external, and co-ordination with customers seems more important than that with suppliers.

3.2 Factor and cluster analysis of drivers

To identify different dimensions in the data material, a factor analysis of driver variables for implementation is conducted. A principal component analysis results in a Kaiser-Meyer-Olkin (KMO) value of 0.825, which is characterised as meritorious (Kaiser, 1974). Furthermore, it is unlikely that the correlation matrix is an identity, because Bartlett’s test is significantly large. All variables are usable in the analysis as the communalities do not reveal any extreme values (Table IV). The correlation matrix reveals that all variables except one are correlated to at least one other variable for a value of 0.3 (significance level 0.01). The last variable is correlated to another variable for a value of 0.2. Rather than including this variable in any of the other factors, we choose to keep it as it is, since we suspect that this variable may be important for the creation of clusters further on.

A scree plot indicates that it is relevant to use six factors. Interpretation of the rotated component matrix results in the following driver factors (Table IV):

1. more efficient inventory control and improved delivery service;
2. improved co-ordination of material flows;
3. enable efficient replanning and handling of product returns;
4. improved traceability;
5. external requirements from customers and authorities; and
6. reduced counterfeiting or theft.

These factors explain 79.7 per cent of the variance of the drivers (Table IV). To investigate whether the data include distinct groups with different drivers a cluster analysis is conducted. It uses Ward’s method with squared Euclidean distance and standardised $z$-scores. A plot of change in Ward’s coefficient indicates that four

<table>
<thead>
<tr>
<th>Table III. Descriptive statistics for drivers</th>
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</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Improve inventory control</td>
</tr>
<tr>
<td>Improve delivery service</td>
</tr>
<tr>
<td>Improve traceability</td>
</tr>
<tr>
<td>Improve co-ordination of internal material flows</td>
</tr>
<tr>
<td>Improve co-ordination of material flows to customers</td>
</tr>
<tr>
<td>Improve co-ordination of material flows from suppliers</td>
</tr>
<tr>
<td>External requirements from customers or authorities</td>
</tr>
<tr>
<td>Reduce staff costs</td>
</tr>
<tr>
<td>Minimise errors in data capture</td>
</tr>
<tr>
<td>Increase efficiency in data capture</td>
</tr>
<tr>
<td>Reduce risks of counterfeiting or theft</td>
</tr>
<tr>
<td>Improve handling of product returns</td>
</tr>
<tr>
<td>Enable rapid replanning</td>
</tr>
</tbody>
</table>
clusters would be suitable for an analysis. A box plot of four clusters is used to visualise differences between the clusters. To name the clusters, factor values versus clusters are reviewed and this results in the following four clusters of drivers for implementing unique identities:

1. co-ordination of material flows;
2. product returns and traceability;
3. external requirements; and
4. reduce counterfeiting or theft.

<table>
<thead>
<tr>
<th>Factor 1: more efficient inventory control and improved delivery service</th>
<th>Factor loading</th>
<th>Eigenvalue</th>
<th>Percentage of variance</th>
<th>Cumulative percentage</th>
<th>Communality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved inventory management</td>
<td>0.790</td>
<td>5.23</td>
<td>40.25</td>
<td>40.25</td>
<td></td>
</tr>
<tr>
<td>Reduced labour costs</td>
<td>0.734</td>
<td>5.23</td>
<td>40.25</td>
<td>40.25</td>
<td></td>
</tr>
<tr>
<td>Improved delivery service</td>
<td>0.723</td>
<td>5.23</td>
<td>40.25</td>
<td>40.25</td>
<td></td>
</tr>
<tr>
<td>Minimise errors in data collection</td>
<td>0.713</td>
<td>5.23</td>
<td>40.25</td>
<td>40.25</td>
<td></td>
</tr>
<tr>
<td>More efficient data collection</td>
<td>0.707</td>
<td>5.23</td>
<td>40.25</td>
<td>40.25</td>
<td></td>
</tr>
</tbody>
</table>

Factor 2: improved co-ordination of material flows

<table>
<thead>
<tr>
<th>Factor 2: improved co-ordination of material flows with customers</th>
<th>Factor loading</th>
<th>Eigenvalue</th>
<th>Percentage of variance</th>
<th>Cumulative percentage</th>
<th>Communality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved co-ordination of material flows with customers</td>
<td>0.870</td>
<td>1.48</td>
<td>11.35</td>
<td>51.60</td>
<td></td>
</tr>
<tr>
<td>Improved co-ordination of material flows with suppliers</td>
<td>0.691</td>
<td>1.48</td>
<td>11.35</td>
<td>51.60</td>
<td></td>
</tr>
<tr>
<td>Improved co-ordination of internal material flows</td>
<td>0.562</td>
<td>1.48</td>
<td>11.35</td>
<td>51.60</td>
<td></td>
</tr>
</tbody>
</table>

Factor 3: enable efficient replanning and handling of product returns

<table>
<thead>
<tr>
<th>Factor 3: enable efficient replanning and handling of product returns</th>
<th>Factor loading</th>
<th>Eigenvalue</th>
<th>Percentage of variance</th>
<th>Cumulative percentage</th>
<th>Communality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved handling of product returns</td>
<td>0.784</td>
<td>1.17</td>
<td>8.99</td>
<td>60.59</td>
<td></td>
</tr>
<tr>
<td>Facilitate faster replanning</td>
<td>0.622</td>
<td>1.17</td>
<td>8.99</td>
<td>60.59</td>
<td></td>
</tr>
</tbody>
</table>

Factor 4: improved traceability

<table>
<thead>
<tr>
<th>Factor 4: improved traceability</th>
<th>Factor loading</th>
<th>Eigenvalue</th>
<th>Percentage of variance</th>
<th>Cumulative percentage</th>
<th>Communality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved traceability</td>
<td>0.888</td>
<td>0.99</td>
<td>7.57</td>
<td>68.16</td>
<td></td>
</tr>
</tbody>
</table>

Factor 5: external requirements from customers and authorities

<table>
<thead>
<tr>
<th>Factor 5: external requirements from customers and authorities</th>
<th>Factor loading</th>
<th>Eigenvalue</th>
<th>Percentage of variance</th>
<th>Cumulative percentage</th>
<th>Communality</th>
</tr>
</thead>
<tbody>
<tr>
<td>External requirements from customers and authorities</td>
<td>0.964</td>
<td>0.88</td>
<td>6.79</td>
<td>74.95</td>
<td></td>
</tr>
</tbody>
</table>

Factor 6: reduced counterfeiting or theft

<table>
<thead>
<tr>
<th>Factor 6: reduced counterfeiting or theft</th>
<th>Factor loading</th>
<th>Eigenvalue</th>
<th>Percentage of variance</th>
<th>Cumulative percentage</th>
<th>Communality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced risk of counterfeiting or theft</td>
<td>0.918</td>
<td>0.62</td>
<td>4.74</td>
<td>79.69</td>
<td></td>
</tr>
</tbody>
</table>

Table IV. Rotated component matrix for factors based on driver variables

To test the relevance of the clustering, a discriminant analysis is performed. The classification results show that 92.6 per cent (87.4 per cent cross-validated) of the cases are correctly classified. The prior probability to explain drivers for companies to implement unique labelling is 25 per cent. Accordingly, the four clusters considerably increase the level of explanation. Some comments on the clusters might be relevant. First, companies in cluster 2 score highly on product returns and traceability, but at the same time have very modest intentions of using unique identities to improve co-ordination of material flows. Second, as Table III shows, the overall mean for the variable counterfeiting or theft is low (1.90). However, some companies, i.e. those in cluster 4, have pointed it out as a strong driver. The mean for this group is 3.94. This clustering would not have been found without the inclusion of factor 6 (Table IV).

3.3 Level of integration for different clusters
Supply chain integration is a key opportunity for companies implementing unique identities. However, depending on the drivers behind implementation, the level and type of integration may vary. Integration as such is a wide concept and there is no single way to measure it. In order to operationalise the concept, we have chosen to assess the number of places in the supply chain where the unique identity is read and registered. This measurement is in line with the packaging perspective chosen for the study. The notion is that the more places the same identity is used in, the more integrated the supply chain.

Thus, to determine level of integration for the companies surveyed, the data in Figure 1 are used. Backward, internal and forward integration are given a score of 0-4. Backward integration is defined as the first three types of registrations, i.e. registration of unique identities by the supplier for own use (score 2 as it is most influential on backward integration), by carrier when delivering goods (score 1), and in relation to delivery notification (score 1). Internal integration is defined as registration types 3-6 with a score of 1 per registration. Finally, forward integration is defined as the last three registration types. The last one, registration by customers for own use, scores 2 because it is judged to influence forward integration the most. The other two registration types score 1 each.

Using these integration levels, a one-way ANOVA test shows that companies in the different clusters have obtained different levels of integration (Table V). Multiple comparisons, using Tukey’s honestly significant difference test, confirm significant differences (0.05 significance level) between the clusters. Table VI provides the median values for integration levels of the clusters indicating differences. Clusters 1 (co-ordination of material flows) and 4 (reduce counterfeiting or theft) are quite similar. In comparison to the other clusters, they are quite integrated on all three levels. Another pair of clusters with similar levels of integration are clusters 2 (product returns and traceability) and 3 (external requirements). Overall, they are less integrated than the previous clusters. Their focus is on internal and forward integration, but on a lower level than clusters 1 and 4. Since the drivers for cluster 2 are product returns and traceability, it is noticeable that companies in this cluster have only obtained a limited level of forward integration.

3.4 Improvements for different clusters
The implementation of uniquely labelled identities has led to improvements for the companies surveyed. To identify results dimensions in the data material, a factor
Four assessments indicate that a factor analysis of all results variables is suitable.

First, Bartlett’s test of sphericity is significantly large. Second, the KMO value is 0.883 (meritorious). Third, the extracted communalities do not result in any extreme values (Table VII), and finally, the correlation matrix shows that all variables are correlated to at least one other variable for a value of 0.4 (significance level 0.01).

A scree plot indicates that four to six factors should be used. To appoint logical labels, six factors are used (Table VII). These factors explain 78.3 per cent of the variance of the results variables.

To distinguish between improvements obtained for the four driver clusters, a discriminant analysis based on the six results factors is carried out. The rotated structure matrix and the group centroids for the clusters indicate differences in improvements secured by each cluster. This classification predicts improvements obtained by companies in clusters 1 (55 per cent), 3 (75 per cent) and 4 (69 per cent) quite well, but only 14 per cent of the companies in cluster 2 are correctly classified. In total, 52.6 per cent of the companies are correctly classified (46.3 per cent cross-validated), which should be compared to the prior probability of 25 per cent. Comparisons reveal that:

- Companies aiming at co-ordinating material flows (cluster 1) have obtained more improvements in inventory management, productivity and delivery quality than the other companies.
Companies aiming at improving product returns and traceability (cluster 2) have a weak indication of improved delivery quality as well as wastage and obsolescence, but companies in this cluster exhibit great variations regarding improvements.

Companies with external requirements for implementing unique identities (cluster 3) have obtained the least number of improvements for all factors.

Companies aiming at reducing counterfeiting or theft (cluster 4) have obtained more improvements in wastage and obsolescence than the other companies. They have also obtained above-average improvements in inventory management, productivity and delivery quality.

The differences above are statistically significant with 99 per cent confidence. There are no statistically significant differences with 95 per cent confidence between the
clusters for the factor “labour cost” and the factor “co-ordination with customers and suppliers”.

3.5 Information sharing
The data indicate that in order to obtain certain improvements of unique identities, the scope and frequency of information sharing are needed. Therefore, these issues are elaborated on.

3.5.1 Scope of information sharing. The potential to increase the level of information sharing regarding unique identities is reflected in who the companies share information with. Information sharing with both customers and suppliers can be potentially increased. Currently, it is most likely that companies share information with their most important customers (mean 3.2). Information sharing with most important suppliers (2.7), the vast majority of customers (2.5), and suppliers (2.1) is less widespread.

Some differences between the clusters are also found. A one-way ANOVA test, descriptive statistics and cross-tabulations with \( \chi^2 \) tests show that companies in cluster 3 have a similar level of information sharing with their most important customers as companies in the other clusters, but significantly lower levels with other types of supply chain actors. Almost no information is shared with suppliers. Using cross-tabulation and \( \chi^2 \) tests also indicates other differences. Companies in this cluster share more information with the vast majority of customers than do companies in the other clusters. Companies in cluster 2 share less information with their most important customers (mean 2.71) than the others. Companies in clusters 1 and 4 share more information with their most important suppliers and with the vast majority of suppliers than companies in clusters 2 and 3. However, we should remember that even though there are differences, all clusters have quite low levels of information sharing with customers and suppliers.

3.5.2 Frequency of information sharing. The frequency of information sharing with customers and suppliers varies within the driver clusters, but some distinct characteristics of the clusters are identified (Table VIII). The median value for companies in cluster 1 shows that most of these companies share information with customers and suppliers on a daily basis based on the use of unique identities. Differences within the clusters are analysed using frequency tables. They reveal that half of the number of companies in cluster 1 share information on a daily basis while 25 per cent share information only in exceptional cases. The median interval for companies in cluster 2 to share information is weekly, but most companies either share information on a daily basis or in exceptional cases. The majority of companies in cluster 3 only share information in exceptional cases. The information-sharing frequency for companies in cluster 4 is slightly higher.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Frequency of information sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Co-ordination of material flows</td>
<td>Daily</td>
</tr>
<tr>
<td>2. Product returns and traceability</td>
<td>Weekly</td>
</tr>
<tr>
<td>3. External requirements</td>
<td>In exceptional cases</td>
</tr>
<tr>
<td>4. Reduce counterfeiting or theft</td>
<td>Twice per month</td>
</tr>
</tbody>
</table>

Table VIII. Median values for frequency of information sharing
3.6 Visions

Having identified drivers for implementation, level of integration and other improvements achieved, information sharing needed, and limitations for obtaining improvements, we provide the companies’ future intentions of using unique identities. These are quite similar for companies in all the driver clusters. However, one of the clusters distinguishes itself from the others. A one-way ANOVA test shows that cluster 3 differs significantly from the other clusters on a number of variables. In general, the means are significantly lower. Cross-tabulation and $\chi^2$ tests indicate that companies in cluster 3 believe that they will obtain fewer improvements in 2-5 years regarding inventory levels, inventory space, service levels, lead time reduction, delivery costs, and co-ordination of material flows internally, to customers and from suppliers, compared to companies in the other clusters.

However, on an aggregated level, the companies surveyed gave internally controllable aspects the highest scores for improvements in 2-5 years. Within this time frame, the companies believe they will improve delivery errors (mean 3.74), information quality (3.64), service levels (3.54), control of internal material flows (3.28), inventory space (3.23), duplication of work (3.21) and lead time (3.20). The lowest scores, on the other hand, were given to change-over time (2.72), capacity utilisation (2.73) and wastage (2.80).

A comparison between improvements already obtained and expectations in 2-5 years indicates a shift in focus. Up until now, companies appear to have focused on improving information quality, eliminating duplication of work and reducing delivery errors. These variables are given similar scores for what is already achieved and for expected improvements. The largest gaps, i.e. differences between near-future expectations and current improvements, regard issues related to internal and backward integration; inventory points (0.53), co-ordination with suppliers (0.50), inventory turnover (0.43) and inventory levels (0.41).

The companies surveyed intend to increase information sharing regarding unique identities with both customers and suppliers in 2-5 years. The highest scores are found for the most important customers (mean 4.08), followed by the most important suppliers (3.74), the vast majority of customers (3.31) and finally, the vast majority of suppliers (3.07).

4. Discussion

This study aimed to highlight drivers behind the adoption of unique identities and its perceived improvements. The data revealed that drivers for implementation seem to play a key role in determining what types and levels of integration may be achieved. This, in turn, appears to affect the extent and nature of logistical improvements obtained through the use of unique identities. In the analysis, we identified four distinct clusters with similar drivers for implementation. Based on cluster affiliation, different levels of integration and improvements have been obtained.

The highest levels of integration were achieved by companies in clusters with drivers to co-ordinate material flows and to reduce counterfeiting or theft. Companies in these clusters have secured high levels of integration internally, backwards and forwards in the supply chain. It is quite logical that companies in these clusters have reached the highest levels of integration as it is in line with their objectives for implementing unique identities. It is, however, noticeable that companies aiming to
reduce counterfeiting or theft have secured high levels of backward integration. These companies appear to take a supply chain perspective, not only reducing counterfeiting or theft forward in the supply chain, but also securing component quality.

These companies with the highest levels of integration also have obtained the greatest levels of improvements. In comparison, companies which aimed at improving co-ordination of material flows have secured the greatest improvements. They have obtained more improvements in inventory management, delivery quality and productivity than the other companies. Companies aiming at reducing counterfeiting or theft have obtained similar improvements, but to a lesser extent. The main difference between these clusters is the level of information sharing. While the first cluster shares information on a daily basis, the corresponding frequency for the latter cluster is twice per month (Table VIII). This is in line with a study provided by the Aberdeen Group (Dortch, 2007) which reports that data sharing is the single most important contributor to the overall result of implementing unique identities.

The lowest levels of integration were achieved by companies in the cluster with the driver to improve capabilities within product returns and traceability, and by those who have fulfilling external requirements from customers or authorities as their driver. Companies in these clusters have obtained a low level of backward integration, and medium levels of internal and forward integration. It is logical that integration focus for these groups is internal and forward. For companies with product returns and traceability as the driver, we expected higher levels of integration in general. However, it should be noted that companies in this cluster have reported very low intentions for using unique identities to improve co-ordination of material flows, which may explain the low level of integration.

Low levels of integration also resulted in a low level of logistical improvements. Companies with external requirements have obtained the fewest improvements. Their overall scores are particularly low. Either their business environment does not offer any potential improvements, or they only implement unique identities with minimal effort due to mandates. Companies aiming at improving product returns and traceability have obtained some improvements in delivery quality as well as wastage and obsolescence.

Compared to other investigations, some of the companies in this study, i.e. those with drivers to co-ordinate material flows and to reduce counterfeiting or theft, have adopted more of a supply chain perspective where the same identity is used in many places along the supply chain. Other studies, e.g. Kotzab et al. (2006) and Kempainen and Vepsäläinen Ari (2003), have shown that companies primarily focus on internal integration. Our study, on the other hand, provides some evidence that the companies in Swedish manufacturing industries with these drivers have achieved backward, internal and forward integration, at least in terms of using a common system for identifying goods along the supply chain.

Another aspect of integration is information sharing regarding unique identities. In general, the scope of information sharing is lower than expected among the companies surveyed. The cluster of companies which aimed at improving co-ordination of material flows, however, scored slightly higher on information sharing of inventory status than the other companies. This may be reflected in the improvements obtained; companies in this cluster scored the highest in inventory management variables such as improved service levels, lead time reduction and reduced inventory levels. The companies
implementing unique identities due to external requirements, those which obtained the fewest improvements, also have the lowest level of information sharing.

The low level of information sharing among the companies surveyed implies that they are far from attaining supply chain visibility. Similar findings were presented by Bagchi et al. (2005). Furthermore, it seems as if Dawe’s (1994) suggestion 15 years ago that there is a substantial gap between available IT and actual IT usage in logistics still exists. The rather low level of supply chain visibility is reflected in the improvements obtained at this point. None of the clusters has reached a mean value of four or five for any of the results variables. However, as previously stated, companies in two of the clusters have reached high levels of integration. Our interpretation is thus that companies in these clusters have started with integration of material flows, but for more improvements to be obtained supply chain visibility needs to be further developed. Therefore, to gain further advantages of unique identities, these companies need to improve information sharing with customers and suppliers regarding inventory status, sales data, location of products, product quality and product returns. Such intentions, i.e. improved information sharing with customers and suppliers in the years to come, are supported in the data. However, more details on the role of information sharing in obtaining advantages of unique identities are needed; for instance, how information should be shared, to what extent and the potential gain of each aspect of information sharing should all be clarified.

On an aggregated level, all companies in the survey expect to obtain more improvements in unique identities within 2-5 years. Much of the current improvements are related to improvements which may be obtained through improved control of internal material flows, such as fewer delivery errors and improved service levels. As opposed to now, the companies surveyed aim to focus more on backward integration in the next 2-5 years. Through co-ordination with suppliers they hope to reduce inventory levels and increase inventory turnover. A logical step after that would be to focus on forward integration. This is, however, not dealt with in the study. Nevertheless, such an approach would offer a structured path towards full integration where potential opportunities are secured gradually. This stepwise approach is in line with stages observed by Gimenez (2006) in the Spanish food manufacturing industry and by Caputo and Mininno (1998) in the Italian grocery sector.

5. Conclusions

Good decision-making relies on accurate, timely and reliable information. This can be supported by assigning unique identities to products and goods in the supply chain. In the survey, 62.5 per cent of the responding companies reported that they use unique identities. There is, however, a significant difference between large and small companies. While 74 per cent of the large companies use unique identification, the corresponding level for small companies is only 50 per cent. This difference can be explained by general differences in technology adoption between small and large companies (Evangelista and Sweeney, 2006). Somewhat more surprising is that the same level of unique identification use is found on all three packaging levels investigated (primary, secondary, load carrier). This contrasts with current literature on RFID (Fish and Forrest, 2007) which indicates that the benefits related to costs of having unique identities on load carrier level are greater than those with unique identities on primary packaging. This would point to a higher implementation level on
load carrier level. However, since our study also covers bar codes and "human-readable" labels, this may be a reflection of the lower investment costs for these technologies, especially for item-level tagging. Bar coding is also found to be the most common method used for assigning unique identities to products and goods in Swedish manufacturing industries, and it is likely that it remains the dominant technology for the near future. Even though RFID functionality is becoming more commonly used and its prices are dropping, it seems as if it will be a complementary technology for some time yet. Potential explanations are that companies are unable to obtain benefits related to RFID technology described in current literature, or that they perceive the additional benefits compared to bar codes as limited.

Moreover, the study shows that there are links between the drivers behind the adoption of unique identities and the level of integration achieved. Four distinct clusters of companies, with similar drivers for implementation of unique identities, were identified in the data. Companies which chose to implement unique identities to better co-ordinate material flows or to reduce counterfeiting and theft experience the highest level of integration, while companies which aimed to improve capabilities within product returns and traceability, or to fulfil external requirements from customers or authorities experience the lowest levels of integration.

High levels of integration are, however, not enough to ensure improvements. The more the integration and information sharing the respondents report, the more the improvements they state they have obtained. Accordingly, companies which are most integrated and share information most frequently, i.e. those with the driver to co-ordinate material flows, achieved the greatest improvements. The second greatest improvements were obtained by companies with the driver to reduce counterfeiting and theft. These companies have similar levels of integration, but share information less frequently. The improvements for the least integrated companies, i.e. those with the driver to improve product returns and traceability and those with external requirements, are quite low. The latter share information the least and also obtained the fewest improvements.

In the coming 2-5 years, the companies in the study expect to secure more improvements in unique identities. Particularly, they aim to focus on backward integration. However, to succeed in obtaining more improvements, the companies need to increase their level of information sharing with suppliers and customers.

The present research contributes to the literature by providing a "snapshot" of the use of unique identities in Swedish manufacturing industries today. Furthermore, the study provides empirical evidence of the links between motivational aspects, level of integration and improvements made, based on the usage of unique identities. While the factors and links in this research are not completely novel, no one, to our knowledge, has studied them in this context before. In fact, according to a comprehensive study by Fabbe-Coste and Jahre (2007, p. 847) only 19 papers in four highly ranked logistics journals "discuss and report on empirical studies of relations between supply chain integration and performance", and the study concludes that current empirical evidence is weak and that more research is needed. Thus, our study makes a modest, but still essential, contribution as it points towards links between drivers behind the adoption of unique identities, the level of supply chain integration obtained, and logistical performance. The findings of the study seem to be representative for Swedish manufacturing industries as the survey study has sampled a large share of the total
population of manufacturing companies and achieved a high-response rate without any detected non-response bias. The resulting links are also likely to be found among companies in other industrialised countries similar to Sweden.

The practical implication of this research is that firms which intend to start using unique identities as a means of achieving increased levels of integration need to mobilise the right organisational motivation first, as this seems to have a major influence on the improvements made. For companies which start using unique identities because of external requirements and adopt a “slap and ship” strategy, the outlook for achieving improvements from their efforts is bleak. The study also provides directions for firms which have already started using unique identities, so that they can reap more benefits from their investments in unique identities. The greater the integration which can be achieved through extended use of unique identities, both internally and by supply chain partners, the greater the number of improvements companies report. Having unique identities which are used by several actors along the supply chain is, however, not enough. The greatest improvements are reported by firms which have not only achieved high levels of material flow integration, but also share the information collected with their supply chain partners.

However, this study, like most research, has some limitations. The focus of this research has been on integration from a packaging and information systems perspective. It is, however, clear that although communication is a key enabler of integration (and by extension, lack of communication is a serious inhibitor), information systems in and of themselves are but one facet of a more complex phenomenon (Pagell, 2004). Further in-depth studies are necessary to provide deeper understanding about how firms are using unique identities on packaging as a mechanism to integrate material flows with their supply chain partners. Moreover, the study as such takes a snapshot in time of the level of use of unique identities, drivers behind adoption, and improvements. Another extension of this research would therefore be to conduct a dedicated study to explore evolutionary patterns towards higher levels of integration in conjunction with packaging. That could be achieved through in-depth longitudinal case studies involving a small number of firms.

References


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