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# A case of shared resources, uncertainty and supply chain integration in the process industry

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**Abstract**

One of the main themes in supply chain management is integration along the supply chain in order to improve performance. This paper contributes to a better understanding of what business conditions determine integrative practices. A framework is developed to investigate what level and scope of integration can be achieved in a supply chain dominated by shared resources, if the type and amount of uncertainty varies for different buyers. This framework is further explored in a case study of a pigment producer and its five main buyers. In general, it was seen that uncertainty increases the need for more integration, while shared resources limit the possibility of reaching a high level of integration. The case clearly shows that shared resources limit the possibility to integration, but also that different levels of integration exist in each of the five supplier–buyer relations depending on the amount and type of uncertainty.


*Keywords:* Integration; Shared resources; Supply chain; Uncertainty

## 1. Introduction

The fundamental value of supply chain management for business improvement is widely acknowledged (e.g. Saunders, 1997; Lysons, 2000; Tan, 2001). An important idea seems to be that integration within and across firms is a pivotal element of supply chain management (e.g. New, 1996; Christopher, 1998). On the one hand, there is some evidence that linking internal processes to external suppliers and customers is a prerequisite for success and a consensus among researchers exists concerning the strategic importance of integration (Stevens, 1989). On the other hand, textbooks (Saunders, 1997; Lysons, 2000; Bloomberg et al., 2002) seem to use terms like integrated supply management and integration too easily and with little precision. Therefore, the concept of integration is open to serious scientific doubts and relatively little knowledge is available on this concept. Recently, Frohlich and Westbrook (2001, p. 185) state "Our knowledge is relatively weak concerning which forms of integration manufacturers use to link up with suppliers and customers". While these authors contribute to our knowledge of integration and integrative practices, little has been done by them or others to better understand the prevailing business conditions for certain integrative practices. Frohlich and Westbrook pay attention to differences in levels and

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types of integration across all suppliers and customers and relate that to performance. Recently, the need for tailoring the supply chain has been recognised (Aitken et al., 2003; Childerhouse et al., 2002). In these two articles, the emphasis is on different supply chains for different *products* in different stages of their product-life cycle. So far, less attention has been paid to what level of integration is achievable if one supplier uses a limited capacity (shared resources) to deliver to a number of different buyers that are part of different supply chains. This paper focuses on the type and level of integration that is achievable with each buyer if the supplier's capacity is shared.

In this paper, business conditions are mainly seen as the characteristics of demand (uncertainty) and the type of resources. Uncertainty is one of the main drivers for close co-operation in a supply chain and especially in cases that are characterised by a lead-time gap (see Christopher, 1998). In this paper, we analyse the impact of uncertainty in volume and in mix and/or specification. With respect to the type of resources, we distinguish between shared resources and buyer-focused resources (Van der Vaart and Van Donk, 2004). A *shared network resource* is a common-capacity source in two or more supply chains or networks (see also Hoekstra and Romme, 1992). Shared network resources are resources (product or process oriented) that are used by a supplier in the network for more than one buyer. Here, buyers competing for the resources seem to be one of the main barriers in achieving integration. This is especially true if the capacity of these resources is scarce. The case of shared resources strongly contrasts with the recently introduced concept of *buyer focus* (Van der Vaart and Van Donk, 2004; Griffiths et al., 2000). Buyer focus can be understood as singling out resources for the purpose of delivering products for one buyer. In that case, integrative practices can easily be achieved along a broad range of activities.

While the above discussion may seem rather academic, this paper also serves a practical purpose. Managers need to know what integrative practices could be beneficial within their circumstances and how to start linking their business to their suppliers or buyers. Better knowledge of both enables choices to be made and helps in improving supply integration. We also argue that it might prevent managers developing integrative practices if no success can be expected.

This paper contributes to the knowledge of what integrative practices are suitable or necessary under certain business circumstances. We limit ourselves to one specific situation: a supply chain that is dominated by the supplier's shared resources and scarce capacity. We concentrate on the link between a supplier and its (main) buyer(s) from the perspective of the supplier, which distinguishes this paper from previous work. The case of shared resources in supply chains has hardly been addressed in the literature, so far. In this paper, we analyse what integrative practices can be realised in such cases, based on the differences in uncertainty in demand for different supply links.

The paper is organised as follows. First, we describe two important aspects of integration: scope and level. Next, we explore the nature of uncertainty in supply chains and develop a framework for the relationship between uncertainty and integrative practices in the case of shared resources. Then, we introduce a case study of a pigment-producing factory. We describe and analyse the level of uncertainty related to the integrative practices for the five main buyers of this factory, along with the influence of the shared resources of this factory. We conclude with a number of general observations and suggestions for further research.

## 2. Integration and integrative practices

The concept of integration within supply chains is not yet well agreed (Saunders, 1997; Lysons, 2000; Tan, 2001; Bloomberg et al., 2002; Frohlich and Westbrook, 2001), although it is seen as a fundamental principle of SCM (e.g. Tan, 2001; Christopher, 1998; Romano, 2003). Instead of adding another definition or summarising other more or less concise and precise definitions of integration, we have chosen to take another angle. From the SCM literature, it is clear that integration is closely associated with performing activities

in several areas in co-operation with other organisations in a chain. Different areas and different directions for integration have been mentioned (Stevens, 1989; Frohlich and Westbrook, 2001; Romano, 2003; Childerhouse and Towill, 2003). The central idea behind our approach is that removing barriers (or boundaries) between organisations seems to be the crucial issue in SCM (see Romano, 2003; Naylor et al., 1999). This can be achieved by developing integrated activities on a number of areas (scope) and with a certain intensity (level) on each of these areas. The distinction between those two aspects of integration gives a workable and pragmatic tool to describe supply chain integration.

Joint activities can be developed in different areas. This is labelled as the *scope of integration*: the number of supply chain areas in which co-operation is developed. Relatively most attention within the supply chain management literature seems to have been paid to purchasing and supply activities or transportation and logistics (Tan, 2001). Others (Cooper et al., 1997; New and Ramsay, 1997) mention aspects such as product development and marketing, but do not elaborate upon these in much detail. Such aspects are mainly dealt with in separate contributions in more detail and in other journals than most of the SCM articles. Still, we consider product development and marketing as dimensions of the scope. Furthermore, we distinguish four logistical areas as separate dimensions of the scope: flow of goods, planning and control, organisation, and flow of information (see Table 1). These dimensions are adapted from Van Donk (2003) and Ribbers and Verstegen (1992), and comparable to the areas distinguished in Romano (2003) and Childerhouse and Towill (2002). Table 1 includes examples of integrative practices within the four logistical areas.

The *level of integration* can be described (in line with Frohlich and Westbrook, 2001) as to what extent an integrative activity is developed. The level of integration applies to each of the areas presented under the scope. As an example, it is clear that a rather high level of integration is reached in planning and control in the case of Multi-Level Supply Control (Van der Vlist et al., 1997). A low level of integration on this dimension is to inform your supplier only about your promotional actions.

Table 1
Examples of integrative practices on four logistical dimensions

| Dimension | Examples of integrative practices |
|---|---|
| Flow of goods | Packaging customisation, common containers, vendor managed inventories (VMI) |
| Planning & control | Joint forecasting and/or planning, multi-level supply control (Van der Vlist et al., 1997) |
| Organisation | Partnership, quasi-firm (Lamming, 1993), virtual firm (Tan, 2001), JIT II (Stock and Lambert, 2001, p. 494) |
| Flow of information | Sharing production plans, EDI, internet, bar coding |

The literature offers limited insights for the necessary conditions for integration. We briefly review some of the important insights.

The well-known purchasing portfolio-approach by Kraljic (1983), for instance, suggests that the need for collaboration and therefore for integration differs. Kraljic states that a purchasing portfolio can be divided into four categories (bottleneck, strategic, leverage, and non-critical items), depending on two variables: the supply market complexity (few or many suppliers) and the financial impact of the purchases. The same kind of analysis can be performed for the deliveries to customers (Hughes et al., 1998, p. 53). Both types of analysis indicate the importance of the relationships with specific customers and/or suppliers. In general, for strategic products, either in selling or purchasing, a company will strive to be sure of a collaborative relationship. Implementing supply chain management practices is a good way to achieve that. On the other hand, there is little need for close co-operation in the case of non-critical items, unless a cost advantage can be reached.

Another angle on integration is in its relational aspects (e.g. Sako, 1992; Carlisle and Parker, 1989). Mutual trust is a necessity to start with integrative activities anyway.

In addition to the above, the power structure is an important aspect for integration, although the power structure cannot easily be influenced.

Powerful customers just force their suppliers to deliver according to their standards, e.g. JIT deliveries in the automotive industries resulted in a shift in inventories from the assembly plant to the supplier in a number of cases (Sako et al., 1994). Also, retail chains just pass on the uncertainty in demand from their customers to their suppliers. In general, small suppliers or customers will usually not be the partners for integration for larger and more powerful organisations in the supply chain (Bates and Slack, 1998). The above conditions for integration can easily become barriers to integration just as other factors like lack of expertise or costs.

## 3. Uncertainty, shared resources and integration

A number of authors have explored the influence of uncertainty on integration in the supply chain. Davis (1993) distinguishes between three sources of uncertainty: customer demand, manufacturing and supply. Others such as Childerhouse and Towill (2002) and Mason-Jones and Towill (1998) add the control system to those three. Davis suggests that a first stage in improving a supply chain is to know more about uncertainties and to reduce uncertainty in the supply process. Childerhouse and Towill go even further by stating: "An integrated supply chain has minimal uncertainties in all four defined areas" (Childerhouse and Towill, 2002, p. 3503). It should be stressed, however, that their paper studies individual products and their value streams, as opposed to evaluating supply chains with many products. They also realise that the case of shared resources is rather different: "if numerous customers compete for service from a single supplier additional uncertainties are expected" (p. 3507). We submit that this is also the reason why the case of a process industry (with shared resources) is characterised as an outlier: it is supposed not to fit with the other cases (p. 3515). In general, one might conclude that streamlining the process and having more information are seen as integrative practices. However, opposite to Childerhouse and Towill (2002), we submit that a high level of uncertainty is a driving force to aim at more integrative practices and that minimal uncertainty is not a synonym for integration. In our view, in case of perfectly certain demand of customers there is hardly any reason for integration and exchanging information is hardly necessary. In other words, we see uncertainty in demand for a supply chain fundamentally as an exogenous factor, basically caused by the behaviour of consumers/users. Performing integrative practices can mitigate the effect on the supply chain performance. This is in line with, e.g., Lee (2002) and Christopher and Towill (2002), who argue that the supply chain strategy is a reaction to the level of uncertainty (in demand and supply).

An important measure for *supply chain uncertainty* is the lead-time gap (see Christopher, 1998, p. 168). The lead-time gap is defined by Christopher as the gap between the logistics lead-time (i.e. the time taken to complete the process from goods inwards to delivered product) and the customer's order cycle (i.e. the period the customer is prepared to wait for delivery). Hence, the lead-time gap equals zero if a company is able to procure materials, manufacture, and deliver their products within the customer's order cycle. This is rarely the case, and therefore companies need to forecast and/or need to keep inventories in order to handle uncertainty within the lead-time gap. SC uncertainty is high if it is difficult to forecast demand, and/or high inventories are necessary to buffer against uncertainty. In these cases, there is a need to strive for integration within the supply chain. The level of integration needed depends largely on the amount of uncertainty within the supply chain. In this paper, we discuss the impact of the different kinds of uncertainty on the allocation of capacity and the need for integration in a supply chain (see Table 2). Here we adapt an approach by Aitken et al. (2003) and Childerhouse et al. (2002) (based on Christopher and Towill, 2000), who characterise products by volume, variety and variability. In the business-to-business relationship, that we seek to understand, products are mostly unique for specific buyers, variety in itself is less important. However, it is important to know what products have to be produced (the specification and the mix) and how much capacity needs to be planned or reserved (volume).

Table 2
A framework for integration in case of shared resources and different levels of uncertainty

| SC uncertainty | Impact | Integrative practices |
|---|---|---|
| Low-volume, low mix/specification | Necessity to integrate is absent | Mainly restricted to physical flow, simple operating procedures |
| High-volume, low mix/specification | Supplier has difficulty in capacity planning, buyers are reluctant to future commitments | Stocks, practices to improve physical flow |
| Low-volume, high mix/specification | High obsolete risks, capacity requirements stable, broad scope and high level of integration is necessary | Capacity reservation or buyer-focused operations enables broad scope and high level |
| High volume, high mix/specification | Stocks and capacity reservations are not feasible options, shared resources as important barrier | Information exchange crucial, supplier orchestrates the different links with buyers |

Information about the timing and availability of volume and specification/mix is thus required. We therefore distinguish between two kinds of uncertainty: volume uncertainty and uncertainty in mix and/or specification. In both cases, uncertainty is closely associated with the lead-time gap. Our distinction of two aspects of uncertainty refines the approaches of Lee (2002) and Christopher and Towill (2002).

In general, shared resources will be a barrier for integration in a supply chain and specifically if different buyers need to be supplied. If there is more uncertainty, shared resources become more and more important barriers for integration and attuning activities between supplier and buyer will be limited. We suppose that in case of shared resources, capacity co-ordination will be more important than material co-ordination. Uncertainty in material can be solved by applying Multi-Level Supply Control (Van der Vlist et al., 1997). Predicting and planning the capacity needed and allocating the capacity of its resources over time is difficult for a supplier, if buyers are unable to predict future demand on an aggregated level (volumes), specifically if the capacity of these resources is scarce or, more generally, if the volume flexibility of the supplier is limited. Most buyers are not willing to commit themselves to future purchases even if they can predict some part of their future demand.

Starting from the above more general statements about uncertainty and shared resources, we will now evaluate four distinct situations: low and high uncertainty in both volume and specification. For each situation, we consider what type(s) of integrative practices can be expected or will be suitable. The result of this analysis is the framework as summarised in Table 2. We use it to explore and analyse our findings in the case study in the subsequent section.

The first and most simple situation is characterised by low uncertainty both with respect to volumes as with respect to mix and/or specification. The supply chain members may develop simple ordering procedures (continuous replenishment, quick response), working together in optimising the control of inventories (e.g. Vendor Managed Inventories), and try to optimise the physical flow (e.g. Kanban). Shared resources hardly influence the type of practices here. These findings are in line with the recommendations of Aitken et al. (2003) and Lee (2002), who propose in case of low uncertainty Efficient Supply chains.

The second situation is characterised by high volume and low specification/mix uncertainty. Now, allocation of capacity is difficult but not that crucial in supply chain planning and control. The use of stocks is a feasible option and can be used to decouple the two stages in the supply chain (cf. Christopher and Towill, 2002), i.e. the supplier's production planning and the buyer's procurement process. The risks of keeping stocks are limited in this situation. This means that there is little integration necessary in terms of

information exchange, planning and control and organisation. In fact, integrative practices might be restricted to the physical flow of goods, such as attuning delivery sizes or packaging customisation.

The third situation is the one in which SC uncertainty is restricted to the required mix and/or the specifications of the requested products, while overall volume is rather predictable. In this situation stocks are no option, because the risk of goods becoming obsolete is too high. But if buyers and supplier are able to predict the capacity needed (because uncertainty in volume is low), there are possibilities for buyers and suppliers to agree upon the reservation of capacity. If parties choose this line of action, integration becomes much easier, because the reservation of capacity in a sense removes the barrier that originates from shared resources. The automotive industry is a typical example of this type of situations. Volumes are relatively stable, but suppliers need to be able to provide a high level of mix flexibility. The OEMs within the automotive industry, however, focus on reducing costs and seem to be reluctant to get engaged in commitments in the form of capacity reservations. Here the use of dedicated facilities, capable in being flexible in volume, mix and lead-time, can be a solution. Recent work on buyer-focused operations (Van der Vaart and Van Donk, 2004; Griffiths et al., 2000) seems to show that. It should be noted that a prerequisite is that the supply of raw material is not a problem.

The last situation is a real challenge for buyers and suppliers characterised by high uncertainty in volume as well as mix and/or specification. Both options discussed (capacity reservation and keeping stocks) are not viable options, anymore. In this type of situation we would prefer a high level of integration also with respect to supply chain planning and control. However, the shared resources in the supply chain or network are important barriers. Integration with multiple buyers interferes with the production planning of the supplier. This discussion leads us to believe that this challenge can only be met by providing the supplier with the necessary tools and information. The supplier is the only party that is really able to orchestrate the links with his various buyers in the supply network. Buyers should provide the supplier with the necessary information and the supplier should seek all options to increase the degree of flexibility provided. We are well aware that the way the supplier will orchestrate this part of the supply network depends largely on the power structure of the network. Usually, large buyers will be offered more flexibility, while the small buyers will experience less. This situation can be characterised as having a high need for, but relatively low possibilities for integrative practices with all buyers.

Based on the discussion in this section, we conclude with the following statements. If both parties in a business-to-business relationship value their relationship as strategically important and supply chain uncertainty is high, then a collaborative relationship with a broad scope and high level of integration are appropriate. However, shared network resources always limit the possibilities for integration. In case of shared resources, the type of uncertainty determines the appropriate supply chain strategy, and scope and level of integration, as summarised in Table 2.

## 4. Introduction to the case study

The supplier under study is a relatively small part of a large multinational. The supplier is independently producing and selling granulated pigments that are used in a variety of synthetic/plastic products. The products are relatively important for most buyers, as colour is quite important for products such as parts for the automotive industry, domestic appliances and packaging materials. The product variety is unlimited and most products are produced for one buyer only. Quite a few buyers just order once a year. The total volume is rather stable on a monthly basis. Products are either produced on demand (for buyer-specific one-off products) or made to stock (standard products with regular demand). The standard products account for roughly 20% of the orders and 60% of the turnover. The remaining orders are orders for the so-called specialities. The products are relatively expensive and quality (conformance to specifications) is very important.

### 4.1. Data gathering

The approach taken to gather the material is comparable to that of the Quick Scan Audit, as used in Childerhouse and Towill (2002, 2003), using a variety of data-gathering techniques: process mapping, semi-structured interviews, studying and observing procedures and analysing production-related data as recorded in the company's information systems. The supplier was studied during a period of 4 months, with about ten site visits. Both the length of the period and the use of different methods, interviews with different persons from various departments and the combination of qualitative and quantitative data made validation of data possible. Further validation of findings was accomplished by comparing findings from different sources, measured in different ways, and by combining the opinions from different people from various departments (production, planning, sales). Further triangulation of the data was obtained by presenting the findings for the management of the plant and writing an extensive report, that forms the basis for this article. No data were obtained from the buyers of products from this plant.

### 4.2. Supply characteristics

The production process is relatively simple. Raw materials are picked from the warehouse. These raw materials are mixed according to the recipe. Most of the raw materials are always available and used on a very regular basis, others can be ordered within a few days. Supply uncertainty is thus practically absent. After mixing, the product is heated and processed in several coupled steps (including extrusion and cooling). Now the product can be granulated and packed. Large orders need homogenisation after the granulation. A production order can exist of several production batches. For each product, a quality test is performed before extrusion starts, which causes a delay. If the product does not conform to specification, the mix needs to be reworked. As a result, processing times are often uncertain and the production schedule changes quite often. Further, there are high cleaning and set-up times that are sequence dependent (from light to dark colours). In general, utilisation of the machines (including processing, cleaning and waiting time for quality approval) is very high. Due to the high costs of the machine, the aim is to maximise capacity utilisation. Delivery is either within a few days (for standard products) or up to several weeks for specialities, depending on the order level and the lead-time of materials. Important resources are the machines for mixing (6) and extrusion (4).

Planning is based on monthly forecasts from sales (replenishment orders) and actual customer orders. Maintaining the preferred sequence to minimise set-ups/cleaning and meeting due-dates are the principal aims for scheduling. Usually, an order will be rescheduled several times with an average of 1.5, due to quality problems, rush orders and other interruptions of the production process. Still, the delivery reliability is roughly 95%.

Demand is lumpy and one-off for most buyers. Uncertainty (in case of specialities) comes into being through both the specification of the product, the moment of ordering and the amount asked for. Colours are, in general, rather fashionable and buyer-specific, causing relatively many new products.

For the purpose of clarity, we restrict ourselves to the relationship of the pigment supplier and the five largest buyers of their pigments. These five buyers account for 46% of the orders, 60% of total volume and 52% of the total turnover. Table 3 contains a summary of their general characteristics.

## 5. An analysis of integrative practices

The buying companies consider the pigments bottleneck items or in some cases even strategic items (cf. Kraljic, 1983). Moreover, the partners in the different links seem to trust each other. According to the general ideas on supply chain management, the organisations should strive for 'integration' to serve the ultimate customers better. However, in the previous sections we submitted that the shared resources limit the possibilities for integration. In this context, it is important to

Table 3
Characteristics of the five main buyers

| | Domestic Appliances | Compounding | Packaging I | Packaging II | Garment |
|---|---|---|---|---|---|
| Orders (%) | 35% | 4% | 4% | 1% | 2% |
| Volume (%) | 22% | 7% | 6% | 9% | 17% |
| Turnover (%) | 22% | 5% | 7% | 5% | 13% |
| Colours (%) | 11% | 7% | 8% | 1% | 4% |
| Product life-cycle | 3 months—few years | 2.5–3 years | Short (projects) | Long | Long |
| Order cycle | Few days—1,5 week | 10 days | Project | < 1 week | < 1 week |
| Sourcing policy | Single | Dual | Multiple | Single | Dual |
| Relationships | More than 5 years | 2 years | More than 5 years | 10 years | 10 years |
| Stocks | | | | | |
| Supplier | 3 months | 1.5 month | Varies per project (no inventory risk) | 2 months | 6 months |
| Upstream | Very limited | Substantial | N/A | 1 month | 2 weeks |
| Obsolete stock | 6% | 0% | 0% | 0% | 0% |
| Customer-Order-Decoupling-Point | Make-To-Stock (for most products) | Make-To-Order | Make-To-Order (delivery from stock) | Make-To-Stock | Make-To-Order (delivery from stock) |

Table 4
Levels of uncertainty across the five main buyers

| | Domestic Appliances | Compounding | Packaging I | Packaging II | Garment |
|---|---|---|---|---|---|
| Uncertainty (short term) | | | | | |
| Mix/specification | High | Medium | Low | Low | Low |
| Volume | Medium | Medium | Low | Medium | Medium |
| Uncertainty (long term) | Medium | Medium | Very high | Medium | Medium |

realise that efficient usage of capacity requires specific sequencing to avoid long set-up times (cleaning) and that efficiency determines the success of the pigment factory. The framework of Table 2 and the explanation show that the main differences in the level and scope of integration between each of the five links in this case should be attributed to differences in the level of uncertainty. The supply chain uncertainty as experienced by the pigment supplier for each link is summarised in Table 4. The levels of uncertainty are based on the numbers in Table 3 and the regularity in orders as well as assessments from the planners and sales people.

For each of the five buyers, we describe the flow of goods, demand characteristics, and the scope and level of integration. The actual integrative practices within the links of the pigment factory with the five largest buyers are compared with the suitable and feasible practices as summarised in Table 2. In some of the cases improvements are suggested based on the ideas developed.

### 5.1. Domestic appliances

#### 5.1.1. Description

This supply relationship is characterised by intensive collaboration in the development of new colours. Products are ordered by moulding companies, which use the colours to produce parts for Domestic Appliances (see Fig. 1). However, the pigment supplier hardly knows anything in advance about the timing and the amount ordered by Domestic Appliances. The moulding companies just order products with a (agreed) lead-time of a few days. As the pigment plant does not know what Domestic Appliances will produce, a relatively large stock (at relatively high costs) is maintained to be able to deliver the orders of the moulding companies on time. Uncertainty with respect to mix/specification is high as little is known about marketing efforts, production orders of Domestic Appliances, and shifts in buying behaviour of consumers.

#### 5.1.2. Analysis

Despite the experienced uncertainty (high in specification, medium in volume), the level of integration remains low and the scope is narrow. A lack of information leads to unnecessary costs related to the inventory levels and the obsolescence risks, and also results in too many rush orders and deliveries. According to Table 2, information exchange is crucial to enable the supplier to orchestrate the shared resources' capacity for the different supply links. At least, Domestic Appliances should share available information on demand and planning to reduce stocks. Given the moderate uncertainty in volume, one could investigate if applying capacity oriented co-ordination as an integrative practice is possible. If uncertainty in volume can be reduced, buyer-focused operations can enable further integration, according to Table 2.

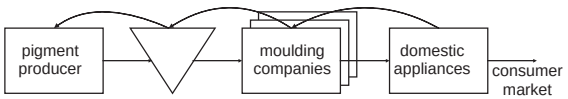


Fig. 1. Flow of goods Domestic Appliances.

### 5.2. Compounding

#### 5.2.1. Description

Compounding prepares materials for the automotive industry by mixing several ingredients. The actual deliveries to the automotive industry are the responsibility of a company called Intermediate (see Fig. 2). Compounding maintains stocks of pigments and works with re-order levels. Some information regarding deliveries to Intermediate is known at Compounding (2–3 weeks horizon), which is partly communicated to the pigment supplier. Deliveries are make-to-order, but often more is produced than is ordered for efficiency reasons. The parties have agreed on a lead-time of 10 days. In case of a capacity shortage at the pigment factory, the lead-time is the result of negotiations. The sharing of information with respect to future demand is reasonably high and beneficial, and Compounding and the pigment supplier share technical information as well.

#### 5.2.2. Analysis

Given the medium level of uncertainty in volume and mix/specification, Table 2 suggests a somewhat higher level of integration. However, Compounding and the pigment producer both keep considerable stocks. The pigment producer alone has a stock cover of 1.5 month. Because of these stocks, uncertainty as experienced by the pigment producer is in fact low. Therefore, it is not surprising that the scope of integration is restricted (only exchange of information) and that the level of integration is not high.

The removal of unnecessary stock points and/or a reduction of stock levels will lead to more uncertainty for the pigment producer and a need for a higher level and a broader scope of integration to guarantee a high supply chain performance. A better attuning of the level of

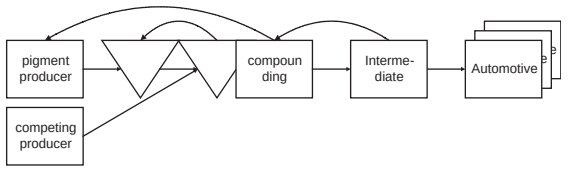


Fig. 2. Flow of goods Compounding.

stocks by means of an integrated planning and VMI is feasible in this situation and will reduce costs in the chain. A capacity-oriented approach seems less attractive. The relatively low volume and the batch processing of Compounding are limitations to that option.

### 5.3. Packaging I

#### 5.3.1. Description

Packaging I manufactures reusable packaging materials for their customers (see Fig. 3). In most cases they are concerned with one-off projects. They use multiple suppliers for the necessary pigments. Some customers of Packaging I require a specific pigment supplier. So it is not surprising that the volume ordered by Packaging I differs per year. Therefore, demand uncertainty on the long run is very high.

In the short run, the specification of products and the requested volumes are known exactly from the moment that Packaging I is selected for a project. Deliveries during the execution phase of each project are regular with some intermediate inventories as a result of batch sizes and the actual demand pattern of the buyer. Information sharing between the pigment factory and Packaging I seems sufficient and the orders are used for efficient capacity utilisation.

#### 5.3.2. Analysis

This link can be characterised as high uncertainty in the longer run, but low uncertainty in the operational stage of a project in the short run. Within each project there is hardly any uncertainty and sale of stocked items is guaranteed. The number of projects varies each year and the timing of projects is difficult to predict. Therefore, integration of activities is restricted to the projects themselves. Given the level of uncertainty within the projects, the narrow scope and the low level of integration are in line with Table 2. The pigment producer uses the orders of Packaging I for capacity utilisation and the batch sizes are based on efficiency only. Reservation of capacity is not necessary and stocks are the result of the batch size used. This link is dominated by efficiency, as expected, and we do not suggest any change.

### 5.4. Packaging II

#### 5.4.1. Description

Packaging II and the pigment producer have a relationship that is quite different from any other. Only two colours are delivered. The average stock at the pigment factory is sufficient to cover 8 weeks production of the buyer. This amount is ordered as soon as the buyer's reorder level is reached (see Fig. 4). The two products are relatively low-quality products and information sharing or co-ordination between the two companies is absent. The production of these products is used for filling up capacity.

#### 5.4.2. Analysis

The activities of the pigment producer and Packaging II are not integrated at all. This is not unexpected given the fact that there is no uncertainty with respect to specification. There is some uncertainty regarding the volume and timing of orders. With a stock cover of 2 months, one can easily cope with this uncertainty. The large stock cover is to some extent acceptable if we consider the fact that the pigment producer uses the products of Packaging II to optimise capacity utilisation. If the buyer and supplier would decide to reduce their stocks, Table 2 suggests a higher level of integration to cope with the uncertainty in volume and timing. This reduction in stock levels might be achieved by sharing more information.

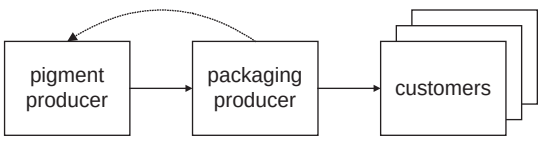


Fig. 3. Flow of goods Packaging I.

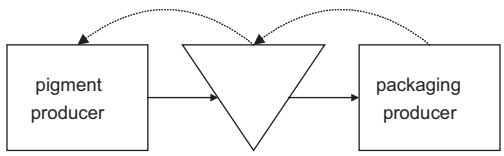


Fig. 4. Flow of goods Packaging II.

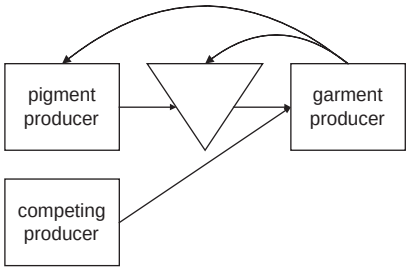


Fig. 5. Flow of goods Garment.

### 5.5. Garment

#### 5.5.1. Description

The fifth supply relationship is with a manufacturer of high-quality garments. Large batches are (as required by Garment) produced to safeguard a constant colour. One batch covers demand for half a year and requires several weeks' production capacity. This reduces flexibility for other buyers during this production run, although production is efficient. Garment guarantees sale of these products. There is some uncertainty in demand with respect to whether the pigment factory or its competitor will supply the next batch.

#### 5.5.2. Analysis

Garment uses a dual sourcing policy with our pigment producer supplying 66% (see Fig. 5). Due to this sourcing policy, there is some uncertainty with respect to timing and volume. The colours, however, are not often subjected to changes. The low level of integration and narrow scope seems appropriate. Crucial in this relationship are the large batch sizes due to the concerns about product quality. The buyer and the supplier are studying possibilities for smaller batch sizes and still guaranteeing constant colours. If this is technically achievable, further integration and a more pro-active relation seems to be feasible to attune the production of the pigment producer and that of the Garment.

## 6. Conclusion and further research

Nowadays, it is more and more realised that a supply chain needs to be adapted to the circumstances and the business conditions. Here, we contribute to that by investigating the integrative practices of a supplier to attune its operations to its main buyers. This paper concentrates on supply chains that are dominated by shared resources: common capacity used for different supply chains. In such cases, integrative practices are hardly possible or feasible, in contrast to what most literature suggests. We submit that efficient and effective supply in case of shared resources depends on the ability of a supplier to co-ordinate his production capacity. The paper develops a framework for the influence of uncertainty on the level and scope of integration, in case of shared resources. A low level of uncertainty in volume and specification/mix is no problem, because integration is not really needed under those circumstances. Higher levels of uncertainty in both specification and volume make close co-operation and integration more necessary, but hard to reach in case of shared resources. Now, the best option is to share as much information as possible with the supplier in order to improve the supplier's ability to orchestrate his capacity as effectively and efficiently as possible.

The concepts are worked out in a case study characterised by the shared resources of a pigment producer. The shared resources clearly limit the level of integration for all links and co-ordination of capacity is important. The five links with the main buyers are analysed with respect to the scope and level of integration and level of uncertainty. The link shows differences in level and scope of integrative practices that can be explained by the level and type of uncertainty in the supply links, confirming our theoretical frame. The limitation for closer co-operation with some of these buyers originates from the shared resources of the pigment producer.

The findings in the case study are in line with what we expected, but more research across more different cases in different industrial sectors need to be performed to limit possible biases from studying only five supplier–buyer relationships in the chemical industry.

Another area for further research is the level of performance associated with different levels of integration. This article suggests that in certain

business conditions a low level of integrative practices is the best strategy to pursue. It might be interesting to further explore the relationship between business conditions, level and scope of integration, and financial and supply chain performance measures.

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