Sales and operations planning in process industries based on types of object, flow and driver

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Abstract

This paper aims to integrate the concepts of object type, flow type and driver type in the context of sales and operations planning (S&OP) with specific focus on process industries (PIs). The object type is related to the discretization point (DiPo) which divides the products in a production process into continuous objects (CO&DO) and discrete objects (Di&Do) and directly affects the resources properties. The flow type looks at the flow of material from the time perspective and can be continuous or intermittent (CF&IF) in the process industries. The driver type initiates the flow of material and is related to the customer order decoupling point (CODP) which divides the production process into forecast-driven (FD) and customer-driven (CD). These three concepts underline the hybridity inherent in the production process. Nevertheless, the planning process of such hybrid systems is a complicated task due to the varying managerial decisions and actions required at each side of the correspondent differentiation point. DiPo is a relatively new concept and its application in the planning process of PIs has not yet been fully realized. CODP, on the other hand, has mostly been dealt with on the strategic rather than tactical level/ S&OP. This paper intends to gather these concepts in an integrated framework with eight building blocks and distinguish the differentiating characteristics of each building block that can influence the design/implementation of S&OP in the process industries. The result is a foundation for a differentiated S&OP process for PIs with emphasis on the competitive priorities of these industries.

Keywords: Sales and operations planning, Process industries, Discretization point, Decoupling point

1. Introduction

Sales and operations planning (S&OP) has mostly been considered as a generic process implying that it is a one-size-fits-all process and independent from the context of the industry it is implemented in. Process industries (PIs); however, have specific characteristics which differentiate them and their planning approaches from the discrete manufacturers. Traditionally, process industries have been looked upon as one integrated entity with a specific set of characteristics. Recently though, the notion of discretization point (DiPo) has been introduced that can be used as a point of reference in the planning processes (Pool, et al., 2011). The physical attribute of the products, which is referred to as the object type, changes from continuous to discrete at DiPo. This aspect is crucial since it affects the types of production processes which are the basis for definition of PIs i.e. mixing, separating, forming and chemical reactions. In other words, these processes are usually performed on continuous objects (Fransoo & Rutten, 1994). Thus, this aspect influences resource management which is an important part of S&OP. However, for planning purposes, not only the physical attributes of the products but also their flow from the time perspective should be considered. Market, production and product characteristics of a company, have great influence on the driver type which initiates the flow of the materials and the position of the customer order decoupling point (CODP) in the production process (Van Hoek, 2001). The three concepts of object, flow and driver types underline the hybridity inherent in the production processes. Nevertheless, the planning process of such hybrid systems is a challenging task due to the varying managerial decisions and actions required at each side of the correspondent differentiation point (Giesberts & Van Der Tang, 1992) (Van Donk, 2001) (Soman, et al., 2004).

The hybridity issue, thus, should be integrated in all levels in the planning hierarchy. DiPo is a concept which can be used for distinguishing discrete manufacturing from PIs and its...
application in the planning process of PIs has not yet been fully realized. CODP, on the other hand, has mostly been dealt with on the strategic level which is concerned with postponement or the positioning of this point in the supply chain (Olhager, 2003) (Van Donk, 2000). Nevertheless, the tactical level, equivalently S&OP, has been discussed in very few papers. This paper intends to provide a foundation for a differentiated S&OP process which takes into account the key properties of the process industries.

The aim of this paper is to integrate the concepts of object, flow and driver types in the context of S&OP for PIs. The aim is to distinguish the specific characteristics influencing the design/implementation of S&OP and to provide the foundation for a differentiated S&OP process for PIs. The focus of this paper is on process industries as defined in 2.1 Process industry.

The rest of the paper is as follow. The next section provides a review of the selected literature. It then continues with the application of the typology to S&OP and introduction of the S&OP integrated framework. The paper ends with concluding discussion and further research.

2. Review of the selected literature

The main focus areas of this paper i.e. process industries and sales and operations planning are explained in the following parts. This section ends with a discussion about the base typology used in this paper.

2.1 Process industry

Process industries (PIs) are production facilities that “produce products by mixing, separating, forming and/or performing chemical reactions” (Blackstone Jr., 2010, p. 115).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Before DiPo</th>
<th>After DiPo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resources</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor intensity</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Lead-time to increase capacity</td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>Yield</td>
<td>Variable</td>
<td>Fixed</td>
</tr>
<tr>
<td><strong>Production facility</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routing</td>
<td>Fixed</td>
<td>Fixed/Variable</td>
</tr>
<tr>
<td>Material handling equipment</td>
<td>Fixed-path</td>
<td>Variable-path</td>
</tr>
<tr>
<td>Layout</td>
<td>Process based</td>
<td>Product based</td>
</tr>
<tr>
<td>Production equipment</td>
<td>Specialized</td>
<td>Flexible</td>
</tr>
<tr>
<td><strong>Capacity utilization</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Priority to preventive maintenance</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Equipment failure effect</td>
<td>On the whole factory</td>
<td>On a machine</td>
</tr>
<tr>
<td>Changeover time</td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>Work-in-process inventory</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material flow</td>
<td>Divergent</td>
<td>Convergent</td>
</tr>
<tr>
<td>Recipe</td>
<td>Variable</td>
<td>Fixed</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Added value</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

*Table 1: Differentiating characteristics before and after discretization point (Noroozi & Wikner, 2013)*
PIs are traditionally considered to deploy process flow production. However, it is recently suggested that they actually are hybrids i.e. in their production process, there is a point where continuous objects (CO) turn into discrete objects (DO) and discrete products are produced (Abdulmalek, et al., 2006). This point is referred to as “discretization point” (DiPo) (Pool, et al., 2011, p. 194).

The flow of materials (from the time perspective) in the PIs’ can be either intermittent (batch) or continuous (Woodward, 1965) (Fransoo, 1993) (Dennis & Meredith, 2000a). If intermittent, there is set-up/cleaning time between subsequent batches. If continuous, there is no set-up time or set-ups are short enough to be neglected. The underlying point is that set-up/cleaning time has a great influence in the planning process of PIs since set-ups are usually long and partly sequence-dependent (Van Donk, 2001) (Taylor & Bolander, 1994); otherwise, this definition is true for both process and discrete industries. Thus, while discussing the differentiating characteristics of process and discrete production, the influential factor is the continuity of the object which affects the choice of the production processes and resources (Fransoo & Rutten, 1994). These characteristics (compiled in “Table 1”) influence the manufacturing planning and control process of PIs (Dennis & Meredith, 2000b).

2.2 Sales and operations planning (S&OP)
S&OP has emerged from MRPII and has been improved since the 1970s (Basu & Wright, 2008). This process usually is considered to be generic (Grimson & Pyke, 2007) and is defined as “a process to develop tactical plans that provides management the ability to strategically direct its businesses to achieve competitive advantage on a continuous basis by integrating customer-focused marketing plans for new and existing products with the management of the supply chain” (Blackstone Jr., 2010, p. 133).

S&OP is a monthly process which aims to create balance or integration between demand and supply plans at an aggregate level (Wallace & Stahl, 2008). The planning horizon can be between three months and three years (Gianesi, 1998) (Grimson & Pyke, 2007); however, most researchers emphasize on a horizon between 12-18 months (Wallace & Stahl, 2008) in order to cover the whole marketing cycle especially for companies with seasonality profile (Grimson & Pyke, 2007) (Jonsson & Mattsson, 2009). Traditionally, S&OP process considers the balance between demand and supply plans. Advanced S&OP process; however, includes the balance of strategic and operational plans through S&OP and integration of financial plans, risk and scenario management, customers, suppliers and competitors in this process (Noroozi & Wikner, 2013) (Viswanathan, 2011) (Wallace & Stahl, 2008).

A formal S&OP process is suggested by several authors such as Wallace & Stahl (2008) and Jacobs, et al. (2011) which has five steps: data gathering, demand planning, supply planning, pre-meeting and executive meeting. The process starts with gathering data for demand and supply planning. Next, a demand plan is prepared which is mainly focused on forecasting the future demand for present and new products. This plan is sent to the next step where capacity planning is performed based on the demand plan (required capacity), available capacity and inventory/backlog levels. In two final steps, people from different related areas in the company gather and discuss issues related to the balance of demand and supply plans and come to an agreement on a final game plan for the company (Wallace & Stahl, 2008) (Jacobs, et al., 2011). From now on, these steps are used as a baseline to unify the presentation of the results of this paper in three groups: demand management, supply management and balancing. This is due to the fact that the first step of the process provides information for other parts and the last step is mainly concerned with confirmation of the game plan.
2.3 Planning typology

In this paper, we use the typology introduced by Wikner & Noroozi (2014) as a basis for outlining an S&OP process. The above mentioned typology is based on flow characteristics rather than the layout and integrates the three concepts of object type, flow type and driver type into a typology. Wikner & Noroozi (2014) suggest that the typology can improve the understanding of the specific characteristics of different manufacturing companies with regard to their supply chain and planning processes and thus, enhance their competitive advantages. So, while Wikner & Noroozi (2014) provide a general framework for manufacturing planning in all types of industries, this paper is only focused on S&OP process in the PIs. As a result, the typology has been modified for PIs and specified for the tactical level. Thus, we end up with a three-dimensional matrix with eight building blocks as can be seen in “Figure 1”. The dimensions are object type, flow type and driver type which are further divided into continuous and discrete objects (CO&DO), continuous and intermittent flows (CF&IF), forecast driven and customer driven (FD&CD) parts respectively.

![Figure 1: The modified typology integrating object, flow and driver type with focus on process industries](image)

In PIs, the production process by nature starts with CO and typically is followed by DO (Abdulmalek, et al., 2006). Furthermore, due to the importance of high utilization and economy of scale for PIs, usually FD heads CD. In general, the CODP is mostly connected to a stock point (Wikner & Rudberg, 2005) and as such, can be located anywhere on the supply chain from suppliers to customers. DiPo, on the other hand, is a transformation point (i.e. a process) and so can occur only in the scope of the production processes (Abdulmalek, et al., 2006) (Van Hoek, 2001). Considering the flow type, having intermittent prior to continuous flow is not common in PIs. Therefore, three hybrid conditions can be considered: FD/CD, CF/IF and CO/DO. These three dimensions underline the hybridity inherent in the production process i.e. hybrid CO&DO, CF&IF, FD&CD or a mixture of all. Although different authors, directly or indirectly, have discussed how hybridity within each dimension influences S&OP, the combination of different dimensions or cross-hybridity and its effect on S&OP has not been covered in the literature. In the next section, this typology is applied to S&OP.

3. Applying the typology to S&OP

The upcoming section is as follow. First, the effects of each part of each dimension and the hybridity within the dimensions on S&OP process are studied. Then we focus on cross-
hybridity and its influence on S&OP. Finally, the integrated framework for S&OP in PIs is provided. It should be emphasized that each manufacturing entity falls into at least one of the eight blocks in “Figure 1” based on its products, processes and markets. Thus all entities are hybrids of each and all of the dimensions.

3.1 S&OP and the three dimensions of the typology
In order to understand the effect of the integrated typology on S&OP, it is crucial to first scrutinize the influence of each dimension separately. This part deals with the interaction between S&OP and object type, flow type and driver type one at a time.

3.1.1 S&OP and object type
As mentioned in 2.1 Process industry, the fundamental difference of PIs and discrete industries (DIs) is the continuity of materials/products. Therefore, all PIs are either of type pure CO or hybrids of CO/DO. Pure DO system (and the corresponding S&OP process) has already been discussed in 2.2 Sales and operations planning (S&OP).

### Attributes

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Typical DO characteristics</th>
<th>Generic characteristics</th>
<th>Typical CO characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand management</td>
<td>Demand forecasting</td>
<td>Sales plan</td>
<td>New products and customers</td>
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<tr>
<td></td>
<td></td>
<td>Marketing plan</td>
<td></td>
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<td></td>
<td></td>
<td>Energy provision and consumption</td>
<td></td>
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<td></td>
<td></td>
<td>Variable yield</td>
<td></td>
</tr>
<tr>
<td>Supply management</td>
<td>Resources</td>
<td>Staff planning</td>
<td>Aligned/Nonaligned resources</td>
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<td></td>
<td></td>
<td>Investment in new resource</td>
<td></td>
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<tr>
<td></td>
<td>Capacity utilization</td>
<td>Production capacity restriction</td>
<td></td>
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<td></td>
<td></td>
<td>Inventory/Backlog level</td>
<td></td>
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<td></td>
<td></td>
<td>Bottlenecks</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Maintenance plans integration</td>
<td></td>
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<tr>
<td></td>
<td>Material</td>
<td>Long lead-time materials</td>
<td>Divergent material flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Variable recipe</td>
</tr>
<tr>
<td>Balancing</td>
<td>Balance of demand and supply</td>
<td>Integration of different parties involved in the process</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2: Generic, DO and CO specific issues affecting sales and operations planning (Noroozi & Wikner, 2013) (Wallace & Stahl, 2008)**

The main goal of S&OP is to balance demand and supply plans. Important factors to consider in S&OP plus the characteristics which are specifically of interest to CO&DO are gathered in “Table 2”. For more information about the generic S&OP process, readers are referred to e.g. (Wallace & Stahl, 2008) (Thome, et al., 2012) (Viswanathan, 2011) (Grimson & Pyke, 2007). Most of the issues related to CO in “Table 2” are of interest to all process industries except yield percentage, variable recipe and divergent material flow. These factors might be specifically considered in e.g. steel, aluminum and chemical industries. The table also highlights the significance of resource management in PIs (Noroozi & Wikner, 2013).

**S&OP and hybrid CO-DO**
As mentioned earlier, most PIs are hybrid CO-DO or pure CO. All factors related to generic S&OP are essentially important for CO since they provide the foundation of the S&OP process. While some of CO characteristics in “Table 2” such as maintenance plan integration and energy provision and consumption can be of interest in DO part, some others such as yield percentage or variable recipe are only relevant to CO. Inventory capacity restriction can
also be applicable in DO part through consideration of a tight maximum inventory level in case e.g. the inventory cost is high or in a lean environment.

### 3.1.2 S&OP and the flow type
Pls can follow intermittent (batch) or continuous flow (Woodward, 1965). The difference lies in the set-up time which affects the choice of the planning system (Olhager & Rudberg, 2002). In most Pls, set-up time has a great influence on the planning process since set-ups are usually long and partly sequence-dependent (Van Donk, 2001) (Taylor & Bolander, 1994). Cleaning is an important part of the set-up time in Pls. Based on the type of industry, e.g. in food or pharmaceutical industries, it can account for up to 50% of labor losses per set-up (McIntosh, et al., 2010).

Olhager & Rudberg (2002) suggest that in comparison to market and product characteristics, the flow type and the process choice are less influential at S&OP level. Nevertheless, they consider that level and chase S&OP strategies would be appropriate for continuous and intermittent flows respectively.

Since in case of the continuous flow the set-up times can be neglected, this issue does not have any influence at S&OP level. This situation can only happen in dedicated production lines. In case of the intermittent flow and due to the fact that S&OP is done at an aggregate level, usually the set-up time between two subsequent product families are taken into account while the set-up time within product families is neglected. Consequently, the objective is to minimize the set-up costs, see e.g. (Feng, et al., 2008) (Omar & Teo, 2007).

For IF companies, cyclic planning has been suggested as an effective way to deal with the fill rates, the inventory levels and the utilization of equipment. At S&OP level, decisions should be made on the length of the cycle time for each product family which is based on the set-up times, available capacity and the desired inventory levels (Pool, et al., 2011) (Soman, et al., 2004) (Fransoo, 1993).

### S&OP and hybrid CF-IF
As discussed earlier, the main issue about the flow type is the set-up time. In case of a hybrid CF-IF system, the issue that can cause problems is a meaningful difference between the capacities of CF and IF parts. If the capacity of the CF part is more than the IF, there should be a buffer between the two parts (Kopanos, et al., 2012) or the production process of the CF part would eventually be halted. If first, the buffer capacity and the perishability of intermediate products should be considered. If second, the start-up of the continuous processes might be very expensive or it should eventually produce in batches (Pool, et al., 2011) (Taylor & Bolander, 1994). In case the capacity of the CF part is less than the IF part, then the IF processes starve meaning loss of capacity and low utilization of production processes which usually is very expensive in Pls. Regarding the S&OP process, the balance of production at two sides, the buffer/inventory levels and the start-up or set-up times/costs should be taken into account.

### 3.1.3 S&OP and the driver type
Based on the driver type, three main demand/supply strategies are defined: FD (make-to-stock), CD (make-to-order) and finish-to-order (FTO). FTO is considered a hybrid of FD and CD and therefore is discussed in S&OP and hybrid FD-CD system.

FD systems usually compete on low prices so performance measures such as cost and productivity are important and they follow the level S&OP strategy (Olhager, 2003) which implies mass production, economy of scale and high utilization of the equipment. In addition, due to market expectations of very short lead-times, these companies keep inventories of end products to fulfill the demand (Olhager, et al., 2001) (Olhager, et al., 2006). This inventory is
used to absorb the demand fluctuations as well. Therefore in these companies, the decisions are taken about the level of production, lot sizes and the inventory of product families in the S&OP process (Soman, et al., 2004) (Wallace & Stahl, 2008).
In CD systems, on the other hand, companies compete on design, flexibility and delivery speed. The important performance measures for these companies are flexibility and delivery lead-times. Hence, they follow the chase S&OP strategy (Olhager, 2003) which implies keeping free capacity and consequently low utilization of the equipment. Based on the expected lead-time from the market and in order to keep the utilization at an accepted level, these companies should decide about the backlog level instead of inventory (Olhager, et al., 2001) (Olhager, et al., 2006). The production and backlog levels are the focus of the S&OP process in these types of companies (Soman, et al., 2004) (Wallace & Stahl, 2008).

Olhager, et al. (2001) took a step further and linked the planning strategies (level, chase, mixed) with capacity strategies i.e. lag, lead and track. They suggest that lag and lead strategies are correspondent to level and chase strategies respectively. This link is important since S&OP is located between the tactical and strategic levels in the planning hierarchy (Wallace & Stahl, 2008) (Olhager & Rudberg, 2002) (Thome, et al., 2012). In addition, the decisions regarding resource planning in S&OP are used as an input (or feedback) to strategic planning (Jacobs, et al., 2011). A level planning strategy implies high utilization of equipment which is in line with the capacity to lag behind the demand changes. A chase strategy implies keeping capacity cushions which is aligned with the capacity to lead the demand changes (Olhager, et al., 2001) (Olhager, 2003) (Olhager & Selldin, 2007). Mix strategy also known as hybrid/combined strategy (Arnold, et al., 1998) is further discussed in 3.2.3 S&OP and hybridity of flow and driver types.

### S&OP and hybrid FD-CD system

The planning and control of PIs in a hybrid FD-CD system is not straightforward. The challenges include the cost of low utilization of equipment, the possibility of decoupling the production process and adding buffers, the capacity of the buffers and the selection of intermediate products, see e.g. (Van Hoek, 1999) (Caux, et al., 2006) (Akkerman, et al., 2010) (Kilic, et al., 2013).

CODP divides the production process into FD and CD parts with fundamentally various characteristics (Olhager, 2003). Before and after the CODP, lean and agile approaches are respectively suitable (Mason-Jones, et al., 2000) (Wikner & Rudberg, 2005). While the lean approach is focused on efficiency and low inventory, the agile approach values flexibility and responsiveness in planning (Sabri & Shaikh, 2013) (Maskell & Baggaley, 2004). Level S&OP strategy is suitable before CODP and chase strategy after this point (Olhager, et al., 2006).

The issue though is to integrate the FD and CD systems into a framework. There are two papers which have considered this issue at S&OP level. Soman et al. (2004) suggest a hierarchical planning framework for food processing industries at three levels: production plan, medium term plan and process. The medium term level eq. S&OP is concerned with the capacity allocation among the products, the inventory levels for the FD products, and order acceptance and due-date setting policies for the CD products. They also emphasize the importance of set-up times and cyclic planning for product families (Soman, et al., 2004).

Rafiei & Rabbaní (2012) suggest a model for capacity coordination model (eq. to the medium term planning) for hybrid FD-CD systems. The model first distinguishes CD products vs. FD or hybrid FD-CD and prioritizes CD products and allocates an initial capacity for these products. This initial capacity plan is used as the basis for deciding the lot sizes for FD and hybrid FD-CD products. At the second level of prioritization and based on the capacity plan, FD-CD products are ranked above the FD ones and the acceptance criteria are applied on CD and hybrid FD-CD products. The output of the model would be the accepted CD and FD-CD
product families, lot sizes and the capacity plan to fulfill the demand (Rafiei & Rabbani, 2012).

3.2 S&OP and cross-hybirdity
Most manufacturing companies are hybrids in terms of applying a mixture of CO&DO, CF&IF or FD&CD. The planning process of these hybrid systems has been a challenge for many researchers and companies (Giesberts & Van Der Tang, 1992) (Van Donk, 2001) (Soman, et al., 2004). In this part, the cross-hybridity between the dimensions is discussed. Still, the main focus is on the process industries.

3.2.1 S&OP and hybridity of object and flow types
From S&OP perspective, these two dimensions are independent since PIs can practically use both continuous and intermittent flow regardless of the DiPo position. In case of the IF, both CO&DO parts should consider the set-up times and lot-sizing problem. Nevertheless, it might be tricky for CO part to apply the chase strategy due to the importance of high utilization. This issue is further discussed in S&OP and hybridity of flow and driver types.

3.2.2 S&OP and hybridity of object and driver types
The main point in this hybrid situation is that DiPo and CODP cannot be located at the same place during the production process since they are related to a process and a stock point respectively. The possible relative positions in PIs are illustrated in “Figure 2”. It should be noticed that in PIs, DiPo cannot be located first since in that case, there would not be any continuous object as required in PIs.

![Figure 2: The relative positions of customer order decoupling point (CODP) and discretization point (DiPo) in process industries (Wikner & Noroozi, 2014)](image)

Having the CODP before DiPo in the production process requires specific attention in S&OP regarding the possibility of decoupling the production process and adding buffers, the capacity of the buffers and the selection of intermediate products (Van Hoek, 1999) (Caux, et al., 2006) (Akkerman, et al., 2010) (Sharda & Akiya, 2012) (Kilic, et al., 2013) which is the case in states three and five in “Figure 2”. State one is slightly different since CODP is located at raw material stock. Process industries have a divergent material flow (Fransoo & Rutten, 1994) and the variety of SKUs usually depends on the packaging options which is related to CODP to a large extent and happens after DiPo. This implies that the explosion point in the material flow is highly connected to DiPo and CODP and thus, CODP is more prone to locate after DiPo. This is the case in states four and six in “Figure 2”. Also considering the properties in 3.1.3 S&OP and the driver type, keeping capacity cushions and following chase strategy are economically
more reasonable in DO rather than CO. The rest of the states i.e. two and seven are representative of pure CD, FD and CO strategies in PIs which have been already discussed.

3.2.3  

S&OP and hybridity of flow and driver types
This cross-hybridity as illustrated in “Table 3”, indicates mismatches when a mixture of CD-CF or FD-IF exists in a production process since they imply two contradictory production strategies i.e. level and chase.

![Table 3: Flow and driver types hybridity](image)

PIs traditionally are considered to apply a pure level and lag strategy due to the importance of high utilization and low cost (Taylor & Bolander, 1994). One option to address this problem could be applying a mix strategy i.e. changing the production level several times during the planning horizon but not as often as in the chase strategy. The application of this strategy is; however, limited in PIs due to the importance of high utilization and long lead-times to increase the capacity.

Mix strategy is in line with the track manufacturing strategy which implies the acquisition of capacity in small steps. PIs are restricted in implementation of this strategy since e.g. working overtime or changing the staff level usually is not possible for them. Nevertheless, other options such as subcontracting, building inventory or short-term control of demand by e.g. initiating sales programs can be considered (Olhager, et al., 2001) (Maskell & Baggaley, 2004).

3.3  

Integrated framework for S&OP in PI
All PIs should consider the issues in “Table 2” in their S&OP process if relevant. The rest of the issues discussed so far are gathered under demand and resource management and balancing in “Table 4” with regard to each of the eight building blocks shown in “Figure 1”. In “Table 4”, backlog level and order acceptance policy are gathered under demand management, and set-up time and inventory belong to supply management. It can also be argued that inventory can be located under demand management since it affects the service level but still, the inventory/buffer cost is a part of supply management. Since level and chase strategies influence the balance between demand and supply, they are located under balancing. The mismatches regarding the cross-hybridity have already been discussed in 3.2 S&OP and cross-hybridity.
<table>
<thead>
<tr>
<th>Building blocks</th>
<th>Demand management</th>
<th>Supply management</th>
<th>Balancing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Backlog level</td>
<td>Order acceptance</td>
<td>Set-up time</td>
</tr>
<tr>
<td>CD-CO-CF</td>
<td>√</td>
<td></td>
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<tr>
<td>FD-CO-CF</td>
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<td>√</td>
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<tr>
<td>CD-CO-IF</td>
<td>√</td>
<td>√</td>
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<td>FD-CO-IF</td>
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Table 4: Important issues in S&OP process with regard to the eight building blocks

4. Concluding discussion and further research
The aim of this paper is to distinguish the specific characteristics influencing the sales and operations planning (S&OP) process and to provide the foundation for a differentiated S&OP for process industries (PIs). To achieve this goal, we have integrated the concepts of object type, flow type and driver type in the context of S&OP Process industries have been emphasized through the continuous object type in this framework. The continuous object type is the crucial factor in the choice of the production processes and resources which consequently have a large influence on S&OP through the resource planning/management. From a planning perspective though, not only the physical attribute of the object but also the flow and its triggers are fundamental. We have gathered these three concepts in an integrated framework with eight building blocks and tried to distinguish the differentiating characteristics of each building block that can influence the design/implementation of S&OP. We have also considered the hybridity within the concepts and between them i.e. cross-hyridity. Even though the effect of hybridity within each concept on tactical planning/S&OP has been discussed in a few papers, the influence of cross-hybridity has not been covered in the literature so far. The results of this study have been presented in alignment with the S&OP steps. In the integrated framework, backlog level and order acceptance policy have been classified under demand management for the related building blocks, set-up time and inventory level are in supply management group and finally level and chase strategy are gathered under the balancing headline. In general, the results show that the focus is more on supply management in PIs which is in line with the great importance of resource management in these industries.

It should be considered that the framework is only based on theory and lacks the empirical results. Implementation of the framework in case companies might result in further refinement and improvement of the model. It might also answer the question whether a tailored S&OP framework should be defined with regard to the three differentiation points which matches the specific requirements and characteristics of PIs and more specifically, the continuity of the object. Another interesting subject would be to combine the presented framework in this paper with the five-step S&OP process, integrate the supply chain partners in the framework and use it in the supply chain context. Even though we have tried to present the results in alignment with S&OP steps, there is very limited information in the literature about demand management and balancing issues.
5. Acknowledgement
The research is performed within the Process Industry Centre (PIC) supported by the Swedish Foundation for Strategic Research (SSF).

6. Bibliography


