

## **Order Penetration Point (OPP): uma análise de conteúdo**

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### **Introdução**

O tema relacionado ao ponto de entrada do pedido do cliente (em inglês Order Penetration Point – OPP) tem tido destaque na literatura acadêmica desde os anos 80. O objetivo desta iniciação científica (I.C.) foi o de pesquisar teoricamente este tema, sob a ótica da Engenharia de Produção, por meio da realização de uma revisão sistemática da literatura usando uma abordagem de análise de conteúdo.

Este relatório apresenta inicialmente um resumo das atividades de I.C. realizadas sob a orientação do Prof. Luiz Felipe Scavarda e co-orientação da doutoranda Paula Ceryno ao longo de Maio de 2012 até janeiro de 2013. O relatório possui em seu apêndice uma cópia do artigo que teve a participação do aluno de I.C. e de seus orientadores. O artigo foi aprovado para publicação nos anais da 22nd International Conference on Production Research (conferência internacional bienal realizada este ano em Foz do Iguaçu).

### **Metodologia**

O método de análise de conteúdo foi adotado para desenvolver a revisão da literatura que permite aos pesquisadores selecionar, filtrar e resumir grandes volumes de dados, facilitando assim a análise desses dados. A revisão examinou as publicações encontradas em bases de dados eletrônicos da “Elsevier” e “Emerald” publicados nos últimos 20 anos (1993 a 2012). Os dados recolhidos foram exclusivamente de revistas científicas dado que os acadêmicos e profissionais geralmente usam essas revistas para adquirir conhecimento e disseminar novos resultados.

De acordo com as recomendações iniciais de pesquisa encontrados na literatura, as palavras-chave escolhidas foram suficientemente “amplas” para evitar resultados indesejáveis. Em pseudocódigo, foram usadas as seguintes palavras-chave como método de busca dos artigos: "Order Penetration Point" ou “Decoupling Point”. O uso dessas expressões pode ter omitido de alguns artigos que abordavam esse tema com outros termos / expressões, porém em função do largo uso e aceitação dos termos mencionados, acredita-se que os artigos selecionados representam parte significativa da pesquisa que está sendo realizada nessa área. Foram estudados trinta e seis artigos, gerando um banco de dados contendo as principais questões abordadas em cada papel, enfatizando as definições de OPP.

## **Order Penetration Point**

Pesquisas associadas ao OPP não são recentes, tendo este tema despertado interesse desde os anos 80. A introdução do termo OPP no contexto logístico se deu através de Sharman (1984) que o definiu como sendo o ponto na cadeia onde as especificações do produto são congeladas, onde o produto se vincula a um cliente específico, e também como o último ponto onde os estoques são mantidos. Assim, o produto não é movimentado até que o ponto de consumo seja conhecido, ao mesmo tempo em que sua customização/personalização somente ocorre quando as preferências do consumidor são determinadas. É importante ressaltar que a definição mais adotada se repete nove vezes dentro do total de artigos estudados, sendo essa "... the point that indicates how deeply the customer order penetrates into the goods" (Hoekstra and Romme, 1992). Apesar disso, todas as demais definições também apontam OPP como o ponto em que o pedido do cliente penetra o fluxo de mercadorias. Também relacionados com diferentes posições do "OPP", existem as principais estratégias de entrega do produto em situações de produção diferentes, como "Make-to-Stock" (MTS) que significa tomar ações com base na previsão, "Assemble-to-Order" (ATO) representando uma estratégia de compromisso, "Make-to-Order"(MTO) onde as ações são tomadas com base na solicitação ou ordem do cliente e "Engineer-to-Order"(ETO) que representa uma estratégia onde são realizadas atividades de engenharia / desenvolvimento para a ordem do cliente. Essas estratégias são orientadas pela previsão e demanda do consumidor.

Com isso, pode-se ser abordado os diferentes aspectos do "OPP", cujos mais relevante estão relacionados com o mercado (requisitos de entrega lead-time, a volatilidade da demanda do produto, volume de produto, a gama de produtos e requisitos de personalização de produtos, volume e frequência de pedidos de clientes), com o produto (o design modular do produto, por exemplo, possibilidades de personalização), e com as características do fluxo de material (o tempo de produção de chumbo, o número de pontos de planejamento, a flexibilidade do processo de produção, a posição do ponto de estrangulamento no processo de produção).

Nesse contexto, os artigos foram classificados como teóricos, empíricos e teórico-empírico, sendo apresentados em ordem cronológica. Os resultados indicam que a maioria dos artigos estudados tem fundamentação teórica (47%). O restante fica parcialmente dividido em 20% empíricos, predominantemente focado na manufatura, e 33% em empírico-teórico.

## **Considerações Finais**

A pesquisa de iniciação científica teve como base uma revisão sistemática da literatura científica sobre OPP. Apesar da inclusão de artigos na análise de conteúdo não ter sido exaustiva, os trabalhos selecionados constituem uma parcela significativa e representativa na pesquisa realizada sobre OPP. Eles servem como uma base abrangente para a compreensão das principais definições assim como suas aplicações, e questões-chave do tema. O estudo destaca a falta de uma definição unânime para OPP entre os pesquisadores, no entanto, eles compartilham um ponto de vista semelhante que rege a base para o OPP. A literatura oferece muitos fatores que

afetam o posicionamento do OPP, sendo os fatores mais importantes aqueles relacionados com mercado, o produto em si, e as características de fluxo de materiais (também associado a produção e cadeia de suprimentos). Observa-se a necessidade de realização de mais estudos empíricos e teórico-empíricos dada a falta de indústrias que a literatura ainda não analisou a fundo.

## **Referências**

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## **Apêndice: Artigo publicado no 22nd International Conference on Production Research**

### **ORDER PENETRATION POINT: A CONTENT ANALYSIS APPROACH**

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#### Abstract

Although Order Penetration Point (OPP) has become more popular over the last decades, attempts to synthesize research within this field have seldom been conducted. Aiming to fulfill part of this gap, this paper presents a systematic review of the literature on OPP using a content analysis approach. Two important electronic data bases were used in this process (Science Direct – Elsevier and Emerald Insight). In pseudo code, the following phrase was adapted to the search engines in each database: “Order penetration point” or “Decoupling point” using as reference the title, abstracts and keywords of the papers. Thirty six papers published between 1993 and 2012 in 23 peer reviewed international journals have been retrieved. Interest in the subject is growing, as evidenced by the number of papers recently published on different aspects of OPP. The paper provides a discussion of main definitions available, the product delivery strategies and identifies the key issues addressed in these researches and remaining gaps that deserve special attention in future research. The retrieved papers are classified in the theoretical, empirical and theoretical empirical dimension, allowing a reasonable comprehensive assessment of research approaches taken in the current body of literature on the subject.

Keywords: decoupling point; supply chain; literature review.

## **Introduction**

Systematic literature reviews are a means of providing an objective theoretical evaluation of a particular topic [1]. A systematic literature review facilitates the identification, evaluation, and interpretation of studies in a given area by examining existing concepts, practices, and theories and ultimately summarising the state of the reproducible research in a specific area [2], [3].

The order penetration point (OPP), also called Customer Order Decoupling Point, or simply Decoupling Point, has already been a topic of interest since the 80's [4], when Sharman [5] defined it as “the point at which a product becomes earmarked for a particular customer, where product specifications get frozen, and is considered the last point at which inventory is held”. Although OPP has become more popular, attempts to synthesize research within this field have seldom been conducted. Within this context, this paper presents a systematic review of the literature on OPP using a content analysis approach over the last 20 years.

This paper is divided into five sections, the first of which this introduction. Section 2 describes the research method used. Section 3 presents the main definitions for OPP and production delivery strategies, while Section 4 offers key issues addressed in the papers classifying them into theoretical, empirical and theoretical-empirical studies. Finally, the last section offers the conclusions of the study.

## **Research Method**

The present research uses the content analysis approach to develop the literature review. This approach allows researchers to select, filter, and summarise large volumes of data, thereby facilitating data analysis [6], being a systematic technique that is replicable by other researchers because it is based on explicit rules [7].

The review examines publications found in the Elsevier and Emerald electronic databases published within the last 20 years (1993 to 2012). The data gathered for this review was exclusively from scientific journals, as academics and professionals generally use such journals to acquire knowledge and disseminate new results [8], [9], [10].

In accordance with recommendations for initial research synthesis found in the literature, the keywords selected were sufficiently broad to avoid artificially limiting results and still provided limitations to avoid undesirable results. In pseudo code, the following phrase was adapted to the search engines in each database: “Order penetration point” or “Decoupling point” using as reference the title, abstracts and keywords of the papers. The use of this Boolean expression in the selection process, of just two electronic databases and scientific journals may have caused the researchers to omit studies that address this theme using other words or terms or that are available in other databases or dissemination source (e.g. theses, dissertations and conference papers), however it is believed that the articles reviewed comprise a reasonably representative and comprehensive body of the research work being accomplished in this area. It is worth

mentioning that the other two names for OPP “Customer Order Decoupling Point” and “Decoupling Point” are already covered within the Boolean expression used.

Thirty six papers have been retrieved. All the selected articles were computer managed. For the purposes of this study, a Microsoft Excel database was designed containing the key issues addressed in each paper. A special effort was given to the OPP definitions to identify a possible lack of a single consistent definition of the concept or a universal accepted definition. The collected papers have been classified in the theoretical and empirical dimension (see scheme developed by Olsen and Ellram [11], Croom et al. [12] and Luo et al. [13]), allowing a reasonable comprehensive assessment of research approaches taken in the current body of literature on the subject by highlighting both the basic methodology used and the aim or focus of studies.

The next two sections present and analyse the results obtained from the systematic review.

### OPP definitions and product delivery strategies

Figure 1 presents the 36 papers retrieved for the systematic review analysis. Interest in the subject is growing, as evidenced by the number of papers recently published in the last years, reaching its pick in the last 3 years. Together these three years cover approximately 40% of the total number of publications along the last 20 years.

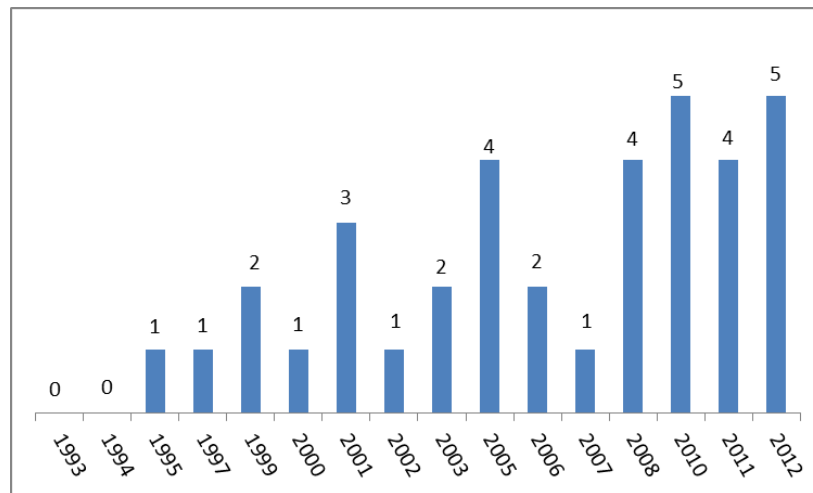


Figure 1: Number of publications on OPP by year.

Main OPP definitions are depicted in Table 1. The first column displays the considered references, while the second presents the definitions themselves and the third provides the other papers that have adopted the mentioned definition in their work. The third column embrace the retrieved papers.

Table 1: Main OPP definitions

Reference	Definition of OPP	Papers that adopted the definition
[14]	“... the point that indicates how deeply the customer order penetrates into the goods.”	[15]; [16]; [17]; [18]; [19]; [20]; [21]; [22]; [23]
[5]	“... the point where product specifications typically get frozen, and as the last point at which inventory is held.”	[24]; [25]; [26]
[24]	“... the point in the manufacturing value chain for a product, where the product is linked to a specific customer order.”	[27]; [28]; [26]
[15]	“... the point at which strategic stock is often held as a buffer between fluctuating customer orders and/or product variety and smooth production output.”	[29]; [30]
[31]	“... the point in the product axis to which the customer’s order penetrates.”	[32] ; [33]
[34]	“... means that the production process is divided into a number of phases and that for each of those it is decided whether or not production is to customer order.”	[35]
[36]	“... the point in the flow of goods where forecast driven production and customer order driven production are separated.”	[37]
[38]	“... some place between supply chain forecast-driven and supply chain demand-driven	[39]
[40]	“... the stage in the production line from where production is on order (i.e. not based on forecast).”	
[32]	“... the position in the material pipeline where the product flow changes from push to pull.”	
[41]	“... the point at which real demand penetrates upstream in a supply chain.”	
[42]	“... the point in the production-process that indicates how deep an order penetrates the flow of materials. It is the point that separates the activities based on forecasts from those based on orders, and impacts the subsequent logistics structure.”	
[43]	“... the breaking point between productions for stock based on forecast and customization that respond to customer demand.”	
[44]	“... a physical point in the value chain of the production system, which separates the investment stage from the realization stage.”	

[45]	“... a push–pull boundary in the supply chain.”
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In the academic literature there is no unanimous definition for OPP. The most adopted definition within literature is proposed in [14] “... the point that indicates how deeply the customer order penetrates into the goods”, being mentioned in nine articles. The others definitions are mentioned at most three times in the retrieved papers set. Most papers propose definitions that are not adopted in others articles. However, every proposed definition embraces the supply chain perspective and they point the location of the OPP as the point where the customer order penetrates the flow of goods. Another important fact that appears in most of the definitions is the separation in the flow of goods where forecast driven production and customer order driven production. Product delivery strategies are related with the position of the OPP, since these strategies determine the point of the supply chain guided by forecast and by demand.

Figure 2 presents the main product delivery strategies in different manufacturing situations such as Make-to-Stock (MTS), Assemble-to-Order (ATO), Make-to-Order (MTO) and Engineer-to-Order (ETO), all relate to different positions of the OPP [24]. The dotted lines on Figure 2 depict the production activities that are forecast-driven, whereas the straight lines depict customer-order-driven activities.

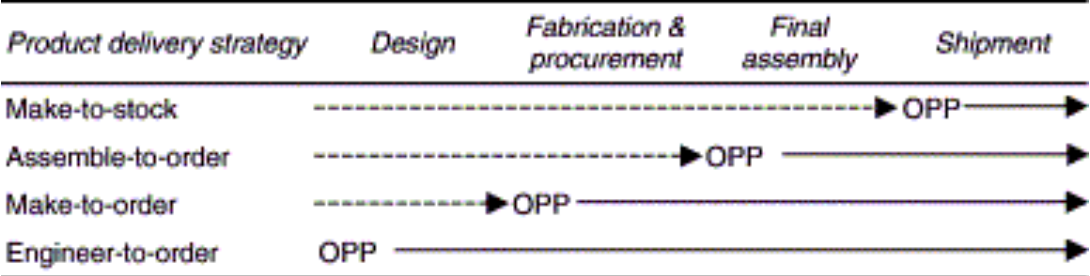


Figure 2: Different product delivery strategies relate to different OPP [24].

The literature provides a brief review of them [21], [44]. MTS: means to take actions based on the forecast, and a workstation can produce if and only if the workstation is idle and the trigger information is available; ATO: can be seen as representing a compromise strategy where some activities are demand driven and the rest are forecast driven; MTO: means to take actions based on the request or actual customer order; ETO: represents a strategy where engineering activities are performed to customer order. However there is some confusion in the writings between make-to-order (MTO) and BTO [46]. The lead times are longer in MTO than in BTO. In MTO, components and parts are made and then assembled. In the case of BTO, the components and parts are ready for assembly. There are a noticeably limited number of research papers on BTO from both academics and practitioners.

Postponement can be applied to move the OPP downstream closer to the consumer, increasing supply chain efficiency and effectiveness [15]. There are many advantages of the strategy of postponement. Firstly, inventory can be held at a generic level so that there will be fewer stock-

keeping variants and hence less inventory in total. Secondly, because the inventory is generic, its flexibility is greater, meaning that the same components, modules or platforms can be embodied in a variety of end products. Thirdly, forecasting is easier at the generic level than at the level of the finished item. This latter point is particularly relevant in global markets where local forecasts will be less accurate than a forecast for world-wide volume. Furthermore, the ability to customize products locally means that a higher level of variety may be offered at lower total cost, enabling strategies of “mass-customization” to be pursued [38].

### Key issues addressed

The 36 papers address different aspects of OPP, the next subsections presents the main aspects that should be highlighted. Literature already offers many factors that affect the positioning of the OPP [17]; [24]; [28]. The most important factors affecting the positioning of the OPP relate to Market-related factors (e.g. delivery lead-time requirements, product demand volatility, product volume, product range and product customisation requirements, customer order size and frequency), product-related factors (e.g. modular product design, customisation opportunities), material flow characteristics (e.g. production lead time, the number of planning points, the flexibility of the production process, the position of the bottleneck of the production process). The market characteristics affect product characteristics. The product range and customization opportunities interact with market expectations and result in a delivery lead time that customers require with respect to the product offering. These factors are input to the production function. The product structure can be interpreted in terms of lead time with respect to the operations that need to be performed at each level. The relationship between production and delivery lead times is a major determinant of the OPP position [24].

The papers are classified within this section in theoretical, empirical and theoretical-empirical studies and are presented chronologically, as done in Leão et al. [47] The result analysis indicates that most of the papers retrieved are theoretical (47% of the total). The remaining articles are purely empirical (20%) or both empirical and theoretical (33%). Empirical studies are predominantly focused on manufacturing sectors. This further emphasises the need for more empirical studies on others industry sectors (i.e. oil & gas). Table 2 presents the industries studied in the empirical studies.

Table 2. Applications of OPP

Agricultural machinery	1
Automotive	3
Chemical	1
Electronic	2
Food	3
Healthcare	1
Home appliances	1
Manufacturing companies	2
Maritime	1



MTO industry	1
PC manufacture	1
SME manufactures	1
Telecommunication	1

### Theoretical studies

The focus of the main theoretical studies is presented in this section. Andries and Gelders [40] discuss the importance of order penetration point (OPP) within the development of time-based management and control systems. Herer et al. [29] propose transshipments, as a tactical solution to achieve leagility without postponement, which represent a common practice in multi-location inventory systems involving monitored movement of stock between locations at the same echelon level of the supply chain. Olhager [24] treats the positioning of the OPP from a strategic perspective. Market, product, and production factors are identified that affect the OPP positioning and the shifting of the OPP upstream or downstream in the manufacturing value chain. These factors are included in a model that allows the manufacturing firm to choose the right product delivery strategy. Hull [18] develops a model that describes the performance of supply chains based on their elasticities of supply and demand. The author also considers the impact of rival firms and the impact of a decoupling point on supply chain performance. Wikner and Rudberg [37] provide a more general approach to enterprise integration of cross-functional processes in order to extend the applicability of the customer order decoupling point as a logistics oriented concept. Blecker and Abdelkafi [48] identify and examine the origins of complexity in a mass customization system and to propose an effective application sequence of variety management strategies in order to cope with this complexity. As practical implications the authors present that the complexity can be decreased if managers ensure less dependency between the satisfaction of customer requirements and position of the decoupling point. Ji et al. [43] build a customer order decoupling point positioning mode, focused in mass customization, with the delivery lead time constraint and capacity constraint, aiming at total cost minimization. Kim and Park [21] suggest a conceptual framework for aligning the strategic issues and the structural issues of supply chain management, and also to disclose the effect of E-business application on such an alignment. Where supply chain structural issues is defined as the number of suppliers, number of tiers, the level of SC integration, order penetration point, lead time, and safety stock. Sun et al. [44] position multiple decoupling points of a product in a complicated supply network instead of a supply chain. Based on the bill of materials (BOM) of a product, a mathematical model is developed in order to find the multi-decoupling points in the supply network through MTO and MTS integration, with the objective of minimizing the overall cost subject to satisfying customer delivery time. Naim and Gosling [30] present the testing, exploitation and extension of the paper on ‘leagility’ developed by Naylor et al. [15]. Via a systematic literature review the notable findings are that the 1999 paper has been exploited in terms of its classification of supply chains into lean, agile and ‘leagile’; those terms have been tested via survey and case based empirical research; has been extended beyond the original stock decoupling point exploitation of lean and agile to encompass other forms of ‘leagility’. Wikner

and Tang [21] show that the customer order decoupling point can be an important corner stone of a framework for analysis of the closed-loop supply chain containing both forward and reverse material flows. Olhager [25] investigates the impact of the position and role of the customer order decoupling point on issues of concern for production and supply chain management. Kristianto [49] focus on decision making related to the use of strategic inventory allocation in product platform design. The purpose of the paper is to present a novel approach to managing product variety by considering product and manufacturing strategy, and considering the supply chain benefits. Jeong [45] propose a dynamic model to simultaneously determine the optimal position of the decoupling point and production–inventory plan in a supply chain such that the total cost of the deviation from the target production rate and the target inventory level is minimized. Hedenstierna and Ng [27] expand the body of knowledge by describing the dynamic consequences that arise from shifting the customer order decoupling point upstream or downstream. Nugroho[50] aims to focus on production ramp up modeling on built-to-order (BTO) manufacturers facing customized demand. The general purpose is to present a novel approach to managing collaboration, by considering information exchange between the manufacturer and the supplier. The authors apply feedback control mechanism to analyze supplier responsiveness and customer order decoupling point to represent the need for collaboration. Finally, Choi et al. [51] contribute to research on “postponement” strategy in the context of a global production–distribution system of an automobile manufacturer. It proposes a model that integrates multiple considerations germane to global supply chains. The results show that the choice of optimal shipping point and the right level of postponement under the “decoupling points” strategy in global operations has a significant effect on overall cost efficiency, when decoupling point and postponement timing are considered simultaneously.

### **Empirical studies**

The focus of the main empirical studies is presented in this section. Naylor et al. [15] show by a case study that the application of lean an agile paradigm has to be combined with a total supply chain strategy particularly considering market knowledge and positioning of the decoupling point as agile manufacturing is best suited to satisfying a fluctuating demand and lean manufacturing requires a level schedule. Haan et al. [35] study the Western literature on production systems and production planning strategies in more detail. In their paper the concept of “customer order decoupling point” appears to be of help in understanding the relationship between production systems, planning strategies and level of customization. Morón [23] examines how decision-making process is organised in average Polish companies and how they are prepared to the implementation of the concept of manufacturing to the order, postponement and relative inventory location. Mistry [19] describes the evolution of an integrated ‘lean’ and ‘agile’ supply chain process that employed Just-in-time (JIT) lean manufacturing approaches at an electronics company. The data revealed how specific quality enhancing and lean manufacturing components evolved over a period of seven years in a two stage transition from a ‘lean’ supply chain to one that represented an integrated lean and agile paradigm based on the decoupling point approach. Lyons et al. [20] investigate the opportunities provided by proximate

supply to support build-to-order (BTO) capability and to provide empirical analysis to identify the extent to which supplier parks as a means of facilitating proximate supply can improve supply chain performance and enhance BTO capability in the automotive sector. Rahimnia and Moghadasian [33] show how to apply decoupling point concept in healthcare delivery system. Finally, Hvolby et al. [52] demonstrate through a case study how a simple simulation model can help Small and Medium Size manufactures to identify current and future possible problem areas and assist management in taking the best possible decisions regarding future production strategies.

### **Theoretical-empirical studies**

The focus of the main theoretical-empirical studies is presented in this section. Van der Vlist et al. [53] describe multi-level supply control (MLSC) as a mechanism to facilitate the flexibility by transforming part of supply chain customer driven; it allows to specify gradually and thus to shift the customer order decoupling point well across the boundary to the supplier. Mason-Jones and Towill [32] expand on the traditional material decoupling point methodology and establishes the role of an information decoupling point within the supply chain. The authors demonstrate the business opportunities generated by first recognizing the existence of the supply chain information decoupling point and then learning how to utilize it to gain strategic advantage. van Donk [16] studies a company changing to more customer- (order-) driven manufacturing. In order to help decide which products should be made to order and which made to stock, a frame is developed and applied to find and balance market and process characteristics. The frame is based on the well-known Decoupling Point concept and adapted to the needs of the food processing industry. van Donk [17] develops a frame that is an aid for managers in balancing the factors and characteristics of market and production process that influence such decisions. The frame is based on the general decoupling point concept by Hoekstra and Romme, which is adapted to the specific characteristics of the food processing industry. Van der Vorst et al. [41] apply the concepts of hybrid supply chain strategies and the decoupling point to a poultry supply chain experiencing high demand uncertainty in an inflexible production environment. Several solutions are proposed for this supply chain to cope with high demand uncertainty. Ashayeri and Selen [42] present a unified approach, which combines capacity management with the external market through the customer order decoupling point, for effective capacity management, with the flexibility to position the organization across differing market-orientations, anywhere from produce-to-stock to purchase-and-produce-to-order. Nielsen et al. [54] presents a method to establish time and interdependency of demand rates (the Time- and Interdependent Demand Rate Method), which can improve the planning and control performance as well as the order management performance in a MTO environment. Dias et al. [39] propose a functional framework for maritime mode integration in European automotive supply chain management when considering outbound distribution. Furthermore, the authors provide a readjustment of traditional concepts and terminology with findings that the role of ro-ro port terminals should be considered as decoupling points, poles and postponement platforms. Rafiei and Rabbani [28] present a model to first decide on which product is manufactured upon MTS, which one upon

MTO and which one upon hybrid strategy, considering in the hybrid MTS/MTO context two important decisions: order partitioning and determining Order Penetration Point location. Teimoury et al. [55] propose a production-inventory-queue model and apply it in chemical company. The authors suggest that the solution of the production, inventory and queue problem can help to strategic decision making about supply chain decoupling point. Olhager and Prajogo [56] analyze these improvement initiatives and their impact on business performance. In particular, we explore potential differences between make-to-order (MTO) and make-to-stock (MTS) firms. Finally, Köber and Heinecke [26] define a methodology that combines the advantages of MTO and MTS. The evaluation of the production strategies is based on an industrial case of a global manufacturer of agricultural machinery and is accomplished with the help of System Dynamics.

### **Final Remarks**

This paper offers a systematic literature review on OPP using the content analysis approach. Although this research is not exhaustive, the thirty six selected papers constitute a significant and representative portion on the scientific research carried out on OPP. It serves as a comprehensive base for an understanding of the main definitions, the main topics and research applications, and the key issues addressed in these researches.

The review highlights the lack of a unanimous definition for OPP among researchers; however, they share a similar point of view about OPP definition. Literature offers many factors that affect the positioning of the OPP, being the most important factors ones related to Market-related factors, product-related factors, and material flow characteristics. A lack of consensus in the literature is in the writing between MTO and BTO, where some authors do not distinguish these terms, while others do [46]. Another point noticed was the need of conducting more empirical and theoretical-empirical studies. There are many industries that are not yet covered in the literature, for instance, the oil and gas / petroleum industry.

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